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TEACHER PERCEPTIONS OF TEACHING AND LEARNING WITH LAPTOPS

by

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Abstract

The purpose of the study is to explore teachers' perceptions of what happens to both teaching and learning when students have access to laptop computers in their regular classroom. Participants in the study were experienced teachers entering their first year of a district laptop project.

This case study research employed four data collection techniques: Classroom observations; teacher journaling; notes from informal discussions; and one focus group. The data analysis helped to determine the effect of bringing laptops into the classroom.

Teachers' beliefs about technology in the classroom changed. They found that having laptops in the space where they normally teach core subjects made it easier for them to integrate technology into those curricula. In addition, teachers reported that not only did the provision of laptops allow them to use a more constructivist approach, but that by giving students more control of their own learning; they actually felt more in control.

Dedication

To Mom and Dad, thank you for your unwavering love and support – one that lead me to love school and to love learning from the first day of kindergarten to today. Richard, thank you for being a sounding board and for your attention to detail in the many readings of this paper, and thanks to both you and Dorelle for taking such good care of Kate and Jack when Char and I were busy with our studies and writing.

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To Charmaine, the time between the start and finish of this thesis seemed like a lifetime. We endured through it all, and have grown in many ways as a result of the journey. Thank you for your loving patience and understanding, and for inspiring me in thought and action.

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Table of Contents

Chapter 1: Introduction 1

Purpose of the Study 3

Research Questions 3

Significance of the Study 4

Terminology 5

Chapter 2: Review of the Literature 7

Overview 7

Background 7

A Brief History of Computers in Education 7

Mobile learning initiatives 8

Critics of technology in education 9

Response to critics 10

Effective integration of Technology 11

Pedagogy and technology 13

Teacher Beliefs 16

Conclusion 16

Chapter 3: Research Methods 17

Purpose 17

Research Approach 17

This study: An overview 19

Selection of participants and research sites 19

Role of the Researcher 20

Data Collection 21

Data Analysis 23
Preparing and organizing the data 24
Exploring and coding the database 24
Describing findings and forming themes 25
Validating the accuracy of the findings 25
Limitations and delimitations of the research 25
Assumptions 27
Chapter 4: Findings and Discussion 29
Overview 29
Description of Sites and Participants 29
Overview of themes emerging from the research 39
Change in beliefs, change in actions 40
Shift towards a more student-centered approach 43
Changing classroom environment 52
Increased student engagement and pride 56
Other findings 60
Summary 61
Chapter 5: Conclusion 62
Summary 62
Recommendations 63
Implications for future studies 64
References 65
Appendix A: Participant consent forms and participation letter 70
Appendix B: Screenshots from online website 74
Appendix C: Example of a 'leveled resource' from Forest Park JHS 75

Table of Figures

Figure 1: Laura's River Glen classroom layout. 32

Figure 2: Rick's Lane Way classroom layout. 34

Figure 3: Carly's Forest Park classroom layout. 37

Figure 4: Laptop distribution at River Glen 55

Chapter 1: Introduction

The start of my teaching career in the early 1990's coincided with the installation of several networked computer labs in my high school. While the personal computer (PC) had been a fixture in most schools across North America since the early 1980's, many school districts were just beginning to invest heavily in networked computer labs, spending millions of dollars on what was being billed as the next great technology – like *Victrola* records, radio, television, and the VCR before it – to transform education (Postman, 1995). What followed may have been called transformational, but in many cases the changes that were occurring were not enhancing teaching or learning (Oppenheimer, 2003). Unfortunately, there were many examples of how *Information and Communication Technology* (ICT) was simply used to replace or support existing methods of instruction. Seymour Papert (1996) labeled those who make school policy but are determined to only use technology within the framework of the school system as they know it as *cyberostriches*. These include uses of technology that simply replace worksheets or other drill and practice programs with technology that boasts progressively more sophisticated graphics, levels of customizability, or portability. These are simply mechanisms to facilitate a traditional "read and recall" or transmittal approach.

Fast-forward nearly a decade and schools had access to a growing amount of information on the internet, the technology capabilities had improved greatly, many students had internet-enabled computers at home, but what was happening in the schools had not changed much. My students would file into the lab, all sit facing the same direction, and type out their hand-scrawled rough copies on the plastic keyboard, all the while hoping that they wouldn't see the "blue screen of death" – the frequency of which demonstrated the instability of personal computer (PC) labs that was the norm. That same year, in another part of the school, a teacher had received funding for the design of a new classroom which took a different approach to the integration of technology. Students were not going to use the computers for simply typing and individual research work - they would work collaboratively to design and create multimedia projects on topics that were of interest to them, using appropriate technology when needed. This classroom not only *looked* different from other classrooms and computer labs, but how the student interactions and learning were different as well. Students had plenty of room, so they could move around to arrange themselves in small groups or gather around individual workstations. This enabled them to collaborate on projects and provided the freedom to *create* with the technology. Later, when this teacher moved on to another position, I took on this teaching assignment, inherited the innovative instructional space, and what I learned over the next several years was powerful.

Changing the physical space in which the learning took place changed my perceptions of the potential of technology for learning and changed how I taught. The classes I had taught with technology had always taken place in a traditional lab setting as described above. Students moved in lock-step through the course which I taught with a structure that was as inflexible as the rows of wired, network computers in the lab. With a different classroom, configured in a way that allowed for collaboration and group work, I became more comfortable with designing learning activities which took advantage of this kind of work. I designed more activities that used small groups and project-based learning, included much more peer assessment and peer-teaching, and incorporated a very flexible approach to the curriculum which incorporated increased student choice. In short, my pedagogical style changed significantly as a result of the physical space in which I was teaching with technology. The space allowed for the students to take more control of their own learning – letting them learn *from* and *with* me, their peers, and the technology. Some of the conditions which lead to this effective integration of technology included:

- a physical space conducive to collaborative work among students;
- reliable technology infrastructure - things simply *worked;* and
- a flexible class structure – students focused their project work on topics that interested them.

Today I find myself working in a different city, and my work takes me into many schools where I continue to see computer labs designed in the circa 1990 fashion described above, with the computers being used as they were used over a decade ago, with the ubiquitous computer lab seen by teachers as that nether-region somewhere between recess and the *real* classroom. Yet the research in this area is overwhelming: If we want to integrate technology to enhance curriculum, students need to have access to technology *when* and *where* they need it for relevant, authentic tasks that engage them and challenge them to think critically (Gulek & Demirtas, 2005; Penuel, 2006). This type of inquiry is happening in several classrooms, but is certainly not the norm. Schools where laptops are brought into the classroom offer an opportunity to examine whether a change in *where* technology is used for learning makes a difference in teachers' perceptions of *how* it could be used. Both large and small-scale research projects have suggested that bringing laptop computers into the regular classroom, for example, may result in a shift in the teacher's pedagogical approach, and in technology being integrated into the curriculum more frequently and meaningfully (Penuel, 2006; Windschitl & Sahl, 2002).

To examine how introducing this technology affected teaching and learning, I have explored what took place at three schools. These schools ventured into the world of wireless computing, where portable computers were available to students in the classrooms they normally worked on Language Arts projects, did science experiments, or discussed issues in Social Studies, for example. Each of the teachers' classes studied also experienced a significant increase in access to technology. Some went from one lab visit per month to having the laptops in their class several times per week, moving from

a scenario where teachers had very limited access to computer labs to one in which teachers have frequent access to carts of mobile computers. Research discussed in the following chapter will suggest that bringing wireless, networked, laptop computers into the classroom will help connect students to each other and to the world around them in a way that moving the students to the computer lab simply could never do (Garthwait & Weller, 2005; Harris, 2004). Reflecting their out-of-school lives, students in such studies reported that they felt more in control of their own learning, were more willing to collaborate with their peers, and felt comfortable using the internet as a primary source of information (MediaAwarenessNetwork, 2005). Further, providing one-to-one laptop access in several studies found that staff could better engage students, students showed improved writing performance, and there were improved teacher-student relationships (Davies, 2004).

Purpose of the Study

The purpose of the study is to explore teachers' perceptions of what happens to both teaching and learning when students have access to portable computers in their regular classroom space. Teacher perceptions lead to teacher beliefs and these beliefs affect practice. If a teacher believes that teaching with technology will help their students, motivate them, give them a deeper, richer understanding of their subject area (for example), this may lead to a change in practice (Ertmer et al., 1999; Windschitl & Sahl, 2002).

Research Questions

Technology has the potential to detract from learning if the implementation is not carefully considered. The pedagogical approach is what is most important, not whether technology is part of the process or not (Papert, 1993). Technology, used to support a poor method of teaching, will not have an effect on student understanding.

Conversely, technology also has the potential to positively impact the teaching and learning process in many ways (Bauer & Kenton, 2005). Several recent studies have shown that laptop computers bring a very different dynamic to the learning-with-technology equation (Alves, 2004; Davies, 2004). This dynamic is influenced by the attitude that these students have towards using technology for learning (Prensky, 2001), and also by the perceptions that teachers have regarding the pedagogical role of technology (Ertmer et al., 1999).

In general, this study explores:

- *What happens in a teaching and learning environment that makes use of laptop computers?*
- *What are teachers' perceptions of the influence this technology has on their teaching AND on student learning?*

More specifically, this study will explore what happens when students in three schools use laptop computers in *regular* classrooms as compared to computer labs. Three urban schools, with students ranging from grades four to nine, were involved in this case study. I collected the majority of my data from three teachers (one at each research site) using a variety of qualitative methods from September 2006 through to May 2007.

Significance of the Study

Several meta-analyses of research on wireless laptop projects have been examined, and there are several benefits that all of these studies have in common (Harris, 2004; Lemke & Martin, 2003; Penuel, 2006). As Parsons reports (2006), when the focus is on the teaching and learning, and not on the technology, and when the necessary supports are in place, we can expect to see:

- Attainment of 21st century skills (e.g. ability to learn independently, collaborate with peers to accomplish work, communicate, think and solve problems);
- improved academic achievement;
- transformation of teacher practice (i.e. less lecture and more individual and group project work, more student-led inquiry and collaborative work, toward constructivist teaching, increases in teachers' use of technology for research, material development, student information management, and collaboration with colleagues, students, and parents);
- improved student attitudes and work habits (i.e. decreases in student absenteeism and declines in discipline problems have also been reported); and
- increased parental and community involvement (i.e. higher attendance at school events and meetings, increased communication via face-to-face means, more volunteering, more participation in tutoring programs and computer classes, increased satisfaction ratings).

In addition, other projects describe an increase in teacher enthusiasm and retention, increases in the quantity and quality of student work, improved writing (in particular), and positive changes in the teaching and learning environment (Harris, 2004; Lemke & Martin, 2003).

Bringing laptop computers into the same spaces where the core subjects are taught may increase how much teachers are willing to build technology-related activities into their lesson plans (Moseley & Higgins, 1999). Even though the research in this area is overwhelming, many teachers continue to either not integrate technology into their teaching at all, or do so in superficial ways. The findings of this research will add to the growing body of knowledge about how wireless, mobile technologies may change both

pedagogy and how students learn by looking at teachers' perceptions. By taking a case study approach, the data will be a reflection of how this particular initiative impacted these specific classrooms in this time and place.

The audience for this research is varied. District and provincial level decision-makers, assistive-technology and technology consultants, and school administrators will want to know if the investment in this type of technology has a significant benefit in terms of measurable gains in student achievement, motivation, or retention. Teachers and teacher-educators will be the main consumers of this research since the findings will provide some insight into the questions above, all relating to effective practice. Describing these perceived impacts can inform other schools who are investigating alternatives for integrating technology effectively into instruction, and may help them to determine whether they wish to move from labs to laptops.

As with all qualitative research, there are limits to the generalizability of the findings of this research. Unlike a quantitative approach, where results from a sample group are extrapolated to apply the result to a large number of people, this type of research describes what happens with a few individual teachers (Creswell, 2005, p. 49). Specifically, this study aimed to deeply explore what was happening in classrooms at the three project sites and not to imply that this was happening with technology integration in general at the school or district level. However, by providing deep and rich descriptions of these cases, readers should be able to draw comparisons to their own situations and determine how these findings relate to their own contexts.

Terminology

- **21st century skills:** These include the ability to learn independently, collaborate with peers to accomplish work, and communicate conclusions of your work as well as information and communications skills, thinking and problem-solving skills, and interpersonal and self-directional skills (http://www.21stcenturyskills.org/).

- **Access Points or AP's**. A base station in a wireless LAN, which is typically a wireless Ethernet (Wi-Fi) LAN. Access points are typically stand-alone devices that plug into an Ethernet switch or hub. If more than one access point is used, like a cellular phone system, users can roam with their mobile devices and be handed off from one cell to another(Ziff Davis Media Inc.).

- **Alberta Initiative for School Improvement (AISI)**. School districts and teachers in Alberta research and design their own school improvement projects, submit their proposals to Alberta Education for evaluation, and if accepted, receive a budget to sustain this project for up to three years (Parsons et al., 2006)

- **One-to-one access:** Also referred to as "ubiquitous access" or "1:1 computing". This is an arrangement where students are provided with a school-owned laptop that is theirs to use (and theirs alone).

- **PDA:** Personal Digital Assistant. Refers to a handheld personal organizer that can also run third-party software.

- **Perceptions:** Used interchangeably with "beliefs" and "attitudes" in the context of this thesis.

- **Portable computers / Portable computing devices:** Also referred to as "laptops" or "laptop computers" in this paper. These devices are high-speed, networked computers with wireless internet connections. The students and staff using the laptops in these case studies can wirelessly access their school network, the internet, and network printers from anywhere in their schools. Other studies may refer to these as "notebook computers".

- **Wireless local area network or WLAN.** A local area network that transmits over the air. It does not require line of sight between sender and receiver. Wireless access points are wired to an ethernet network and transmit a radio frequency over an area of several hundred feet through walls and other non-metal barriers (Ziff Davis Media Inc.).

Chapter 2: Review of the Literature

Overview

In this chapter, I will review significant studies which have focused on technology and its role in teaching and learning. Specifically, the general history of computers in the classroom will be discussed, followed by some of the critical viewpoints on the topic. Next I will review what the literature says about the place and purpose of technology in education, and then narrow in on the impacts of mobile technologies such as laptop computers on pedagogy and learning.

Background

The integration of technology into teaching and learning has been researched and discussed for several decades, but there has yet to be a significant, systemic change in how technology is used to support teaching and learning. While there are pockets of innovation, technology continues to be used to support traditional modes of teaching that limit its effectiveness as a learning tool (Watson, 2001). Today, with several provincial initiatives funding the implementation of pilot projects in schools involving mobile technologies, it is increasingly important to examine the impact of this integration of technology into the classroom, and to add to the growing body of research studying the implementation of mobile technologies (in this case, laptops) into the classroom space. The review of the literature intends to frame the discussion in order to provide both a temporal and situational context for this study.

A Brief History of Computers in Education

In the 1980's, supercomputers and networking capabilities were evolving; incubating what was to become the internet. While few could have predicted the far-reaching potential of the internet in society at large, or in education in particular, Seymour Papert (1993) prophetically talked about the computer changing children's relationship with knowledge producing a revolution comparable to that of the advent of printing and writing. He imagines a machine he refers to as 'the knowledge machine' which would allow children a rich exploration of the world. Primitive examples of this machine would include 'interactive video', 'electronic books' and 'virtual reality'.

When computers first became affordable for the masses in the early 1990's, computer use in schools focused on productivity applications such as word processing and programming. Early computing software was limited and rarely integrated into subject areas. 'Computer literacy' was the focus; learning to read and write in the language of the computer. Schools created computer labs to provide a place for computer literacy instruction at the same time, and in the same place. This type of

setting was effective, at least over the short term (Kulik & Kulik, 1991), but for technology to be integrated into core courses, students require access in the classroom, and more than a couple of times a week (Penuel, 2006). Further, Penuel (2006) reports that teachers were unable to use technology as often as they might have because of difficulty scheduling , and transporting students to the lab. Scheduling is an issue when there is less access to computers than required by staff and students. Presumably access would not be an issue if there were more labs, or in the context of this research, more access to mobile labs of laptop computers in the classroom.

Early research, including a longitudinal study called the *Apple Classroom of Tomorrow* (ACOT) project found technology, when introduced and integrated effectively, could result in several measureable benefits (Schacter, 1999). The type of innovation required involved the effective integration of technology as described by Jonassen (1998), who suggests that to be effective, computers must be an integral part of the entire curriculum, rather than simply an add-on, or a method for delivering instruction. The shift in thinking about the role of technology in learning involves learners interacting with technology in an authentic way, in a constructivist learning environment (Jonassen et al., 1998). In a constructivist environment, students explore and discover the curriculum while working with realistic problem situations, and building on previous knowledge. This provides opportunities for developing critical thinking skills while using computers, as opposed to simply using them to increase productivity (i.e. word-processing replacing hand-writing). Further, Jonassen (1998) proposes that students should use computers in school much the same as people use them in work environments: researching, compiling, analyzing, and publishing.

Alberta Education (2005) has stated: "Technology is part of every student's basic education in Alberta. It's vital that learners are able to gain high-tech skills and knowledge for the future." Two significant events for Alberta were the completion of the 'SuperNet' (the SuperNet provided each school with high-speed, reliable access to the internet), and the implementation of the Alberta Education Information and Communication Technology (ICT) program of studies (Alberta Education, 2005). The ICT program of studies is intended to be a "curriculum within a curriculum" (Alberta Education, 2005), and addressing outcomes as defined by the ICT program of studies requires access to technology. The term "implementation" is used tenuously here as this curriculum was introduced in Alberta without much support, with even less funding, and without a means of assessment as to whether the outcomes identified as crucial in the document were being met.

Mobile learning initiatives

School districts have moved towards wireless technology and providing students with laptops in classrooms with the intention of improving learning opportunities and outcomes for students. McKenzie (2001) argues the freedom and simplicity of working without wires and the fact that laptops can be moved anywhere in the building, is an appealing alternative to desktop machines. Mobile computers can support being

integrated into classroom use and across the curriculum with minimum disruption to existing infrastructure. Some other compelling reasons for using wireless, mobile computers include flexibility, cost saving and expandability. With frequently-changing needs, schools are often required to move classrooms, add portables, and reconfigure computer networks. Wireless technology allows schools to change lab locations and classroom setups frequently and easily. The elimination of the need to wire and rewire can result in some financial savings for schools. As well, by adding on to an existing network rather than replacing the wired with wireless, schools expand their options without losing their initial investment in infrastructure.

As mentioned above, the ACOT project was one of the earliest research projects where all students were provided with access to computers at school and at home. The project started in 1985 and asked the question: "What happens to students and teachers when they have access to technology whenever they need it?" (Apple Computer, 1995). Several initiatives which focused on mobile technologies have taken place in the last two decades throughout North America, most notably the *Maine Learning with Technology Initiative (MLTI)*, where in 2002 over 17 000 students and teachers were provided with laptops (Silvernail, 2005). In Canada, significant projects where students and teachers have been provided with laptops, are in various states of implementation in New Brunswick, Quebec, British Columbia, and Alberta. The findings from this research will be discussed later in this chapter.

Critics of technology in education

When technology is used to simply replicate worksheets or other drill and practice programs, it reinforces a traditional 'read-and-recall' or transmittal approach. This is often referred to as learning 'from' technology. Without a corresponding change in practice to an authentic, problem-based, student-centered approach, in other words, learning 'with' the technology, none of the positive impacts of technology described in the research will have any lasting effect (Papert, 1993). For example, videoconferencing and podcasting are only the latest incarnations of technology to promote the same benefits that the radio and *Victrola* records offered in the 1920's (e.g. 16-millimeter film, closed-circuit television, teacher-proof textbooks, the videocassette player, CD-Roms)(Postman, 1995). Sold as a solution in itself, technology has consistently come up short when not combined with a meaningful change in teaching practice (Oppenheimer, 2003).

In *Fool's Gold: A Critical Look at Computers in Childhood*, Cordes (2000) examines the integration of technology in elementary classrooms and argues childhood is being corrupted by the disproportionate emphasis on technology in comparison to other important initiatives. She makes three essential claims about the influence of computers on young students. She argues:

- the benefits of computers for children are vastly overstated;

- the billions of dollars spent on technology could have a much greater impact on student achievement and success if allocated to other priority areas; and

- the "high tech agenda" poses serious physical, intellectual, moral, and developmental hazards to children.

The report goes on to list a litany of physical and emotional hazards which stem from computer use. These include: Repetitive stress injuries; vision problems; obesity (from a lack of exercise); poisoning (due to toxic emissions and electromagnetic radiation); risks to emotional and social development (including disengagement from parents or peers as a result of being "plugged-in" for hours a day); a loss of self-motivation; loss of wonder; impaired language and literacy; stunted imagination; and poor concentration.

Cuban (in Cordes & Miller, 2000) says "there is no clear, commanding body of evidence...[that technology]...has any impact on academic achievement" (p.3). The article goes much further in contending these "technological gadgets" are seen by teachers as "...convenient, mesmerizing babysitters [which distract] children from adults and from each other [and teach] soon-to-be-obsolete skills" (p.3-4). In reference to the use of laptops in schools specifically, Cuban (2006) rebukes the research on one-to-one laptop programs and argues that most of these outlandishly positive results are from teacher and student self-reports and not from rigorous studies based on persistent observations in classrooms.

Response to critics

In a rebuttal to Cordes' *Fool's Gold* position Abbott (2001) agrees that play, creativity, and nurturing are important in the lives of children, but asserts computers can be effectively used to enhance these features of early childhood education. He describes several examples of how technology is being used with young children to enhance creativity, increase motivation, build collaborative relationships, and foster positive connections with peers and adults. Abbott also refutes the assumption that the mechanistic, mind-numbing methods some teachers are calling 'technology integration' are the norm. Such practices may indeed be happening, but do not reflect best practices and therefore cannot be used as a basis for condemning computer use carte-blanche at early grade levels. He also disputes many causal links to the physical, developmental and moral hazards reported as facts in Cordes' *Fool's Gold* report. That children are being asked, for example, to sit at an uncomfortable work station, keyboard, and stare at a monitor for hours on end is both poor teaching practice and unlikely. Abbott argues if technology is creatively infused into projects as described above by Jonassen (1998), any claims to causal links between technology and the range of hazards to children would be mute.

Davies' (2004) conducted research on a one-to-one computing project where she was in a classroom observing elementary school students for fifty-three days in 2003.

This persistent observation included being connected by email to students and teachers. Data was gathered from observations, products, and interviews and triangulated. Her findings proved students were more willing to work collaboratively with teachers and peers, their writing improved, they were more engaged in their school work, and they spent more time on school work. The findings from this research support much of the self-reported evidence from other studies (including a meta-analysis of research on laptops in education by Penuel (2006)), those same studies that Cuban (2006) discounts due to a lack of persistent classroom observations.

Many studies have looked at how technology has effected student motivation, classroom behaviour, and student interaction with their teachers and peers (Garthwait & Weller, 2005; Penuel, 2006). In addition to finding positive relationships between laptop use and the items mentioned above, Gulek and Demirtas (2005) found that students in a laptop program had significantly higher achievement in nearly all measures (after one year) when compared with students who were not in the program. Specifically, students were more likely to direct their own learning, use more active learning strategies, engage in problem solving and critical thinking, and show more flexible uses of technology when compared to students without laptops.

Effective integration of Technology

> Today's students are no longer the people our education system was designed to teach. These significant changes in our students and their attitudes towards learning must be met with equally significant changes in our approach to teaching practice. Wireless mobile computing devices may provide the impetus for change that our system needs to better meet the needs of today's "digital natives" (Prensky, 2001).

Schools have changed over the past twenty years, and technology has been instrumental. Research in this area is generating more attention from educational scholars as technology becomes integrated into the pedagogy of core courses instead of being a curriculum on the side. Effective integration of technology, mobile and wireless or immobile and wired, requires several factors. In *Celebrating School Improvement: Six Lessons Learned from Alberta's AISI Projects* (Parsons et al., 2006), the authors present the requisite components for successful integration. These include: the support of teachers through the provision of planning and collaboration time as well as reliable technology; effective communication within and outside of the school; technology-embedded professional development; long-term vision and planning; and curriculum activities with an inquiry focus. While these elements are essential to the implementation of any new project, the difference with technology is the profoundly positive effect it can have on student motivation, teacher perceptions of professionalism, and classroom climate when these elements are present (Belanger, May 2000).

The research on technology's effectiveness is divided into two areas: Learning 'with' computers (i.e. using computers as tutors for drill and practice); and learning 'from' computers, where students use computers in the learning process for communicating, collaborating, research, or publishing (Jonassen, 1998). Many of the criticisms of technology in education mentioned above focus on the former, while the majority of the positive results that have been reported concerning the use of technology in education cite the latter type of technology use. A summary of the research for both types of use finds that technology can impact student learning when the following conditions are evident: Students have easy access to the technology; technology is in the classroom, where it can make a greater impact than when it is in labs; ongoing teacher training is provided; and reform of teaching practices is evident, with a balance between traditional instruction, characterized by teacher lecture, and that of construction, characterized by the teacher serving as a guide and facilitator.

Teaching students to become critical thinkers using an inquiry focus is not new, but neither is it the norm in schools despite the overwhelming research supporting this approach (Alberta Education, 2004). High-bandwidth communications, the immediacy of information, and the individualization of programs for students now make it more possible for computers and related technologies to make what once was just the domain of a few excellent teachers, more common practice. Technology could have an effect on whole learning environments by providing the opportunity for knowledge construction and for the communication between learners to build on distributed knowledge (Salomon, 1998). If children are to use computers as tools to solve problems, they need access both when and where they need it. Thus, it is not surprising that technology has not been integrated effectively given students have an hour per week in a computer lab to try and use the computer to aid them in their class work. Furthermore, the inability of teachers to plan tasks that incorporate technology in a meaningful way, has also been inhibited given such limited access.

The effective integration of technology can take many forms. Postman (1995) quotes an old saying in *The End of Education*, "[S]tudents enter school as a question mark and leave as a period" (p.70). If students learn in a school culture of inquiry to develop questioning strategies early in their experience, they will develop problem-solving skills and to be able to think creatively long after they leave high school. Similar collaborative, communicative tools such as discussion boards, chats, or blogs could be used to help share ideas and aid in the brainstorming process. A large-scale example of this would be the growth of social computing, where users collaborate to maintain a collection of communal knowledge (Lamda, 2006). Just as this group of users builds a framework for what they perceive to be correct and true, in contrast with the authoritative voice of the *Encyclopedia Britannica* for example, so might students collectively build a model to show what they perceive as 'true' or 'correct'. Database, spreadsheet, or concept-mapping applications also facilitate the organization of similar ideas.

ICT could allow ideas to be shared across time and space and exponentially increase the critical mass of ideas and creative minds considering the ideas. Access to laptops in the classroom may be more conducive to this type of sharing, because the discussions can take place while students are using the technology in the space where they normally discuss social studies, language arts, or science.

Technology can also support an inquiry focus by allowing students to more easily make and test assumptions. A software application is not judgmental in any sense except that it may tell you that what you have suggested will not work. While a student might be very sensitive to being repeatedly corrected by a teacher or by classmates, the privacy of the interaction between the student and the computer makes the hypothesize-fail-hypothesize cycle bearable for the student. In this sense, "computers offer students a great and important luxury: the opportunity to fail" (Schank, 1988). This requires the ability to fail and to learn from failure. Experimentation becomes less of a risk-taking venture when hypotheses can be tested using a computer simulation. Simulations have inherent boundaries that may be difficult to control in actual experiments, and thus provide a safe environment where students can manipulate variables, tests multiple assumptions, and converge on the understanding of a topic.

Pedagogy and technology

Despite over twenty years of initiatives involving technology in schools around the world, the impact of ICT on schools has been characterized as resolutely disappointing, often placing blame squarely at the feet of teachers. Teachers are often seen as 'technophobic', too traditional in their teaching style, or reluctant to adopt change (Watson, 2001). When teachers do not feel that the use of technology is aligned with the curriculum, they use it less often. Other individual teacher characteristics that affect how much they will integrate technology include their pedagogical approach, their confidence level, and their subject matter expertise (Penuel, 2006).

Some of the influences of computers and technology on teaching and learning reported in the ACOT study include:

- Teachers and students were collaborating more, and teachers were collaborating across disciplines more;
- classrooms became a mix of traditional and constructivist teaching approaches;
- teachers altered their classroom schedules to allow for more time for students to work on projects;
- teachers began to develop new forms of assessment that were more performance and project-based;
- more student-centered, cooperative learning took place; and

- in some cases teachers were inspired to use more complex tasks and materials in their instructions (Sandholtz et al., 1997)

Many longitudinal studies followed students and teachers in the ACOT project and documented how they used technology and also the degree to which it changed how and what they taught. Dwyer (1991) summarizes the developmental stages (identified in the ACOT project) the teachers went through as they gradually began to replace traditional beliefs and practices with new ones. The study concluded that teachers progressed through a continuum of stages in their efforts to integrate technology. These stages included:

1. *Entry* - teachers gain initial information regarding how to use technology in their classroom;

2. *Adoption* – teachers implement technology, but use it to support traditional instructional practices;

3. *Adaptation* – continued use of technology in traditional practices, but increased use of student productivity tools, including word processing software and spreadsheets;

4. *Appropriation* – technology is utilized as a tool to be used for collaborative projects; and

5. *Invention* – technology is utilized in novel ways for instructional purposes.

Movement along the continuum depended upon variables such as collaboration with peers, personal reflection on teaching practices, and training associated with how to integrate technology into every day instruction. Teachers began by using the technology to support traditional didactic instructional methods, which were gradually replaced by more dynamic methods of instruction. Conclusions from this study showed that technology can help classrooms be more collaborative, to enable teachers to act more as guides in a constructivist learning environment, and learn along with the students about the best uses of technology for learning (Dwyer, 1991).

Windschitl and Sahl (2002) conducted a qualitative, multi-case study of three middle school teachers in a laptop school, which examined the relationship between teachers' beliefs about what constituted good teaching and learning, and their use of technology in the classroom. The researchers also sought to understand how teachers developed technology-related practices with peers, and whether or not ubiquitous computing influenced teachers to adopt constructivist pedagogy. They found the introduction of laptops into the classroom, even at a one-to-one computer-to-student ratio, did not inherently move teachers to adopt a more constructivist approach; the decision whether or not to adopt a constructivist paradigm was made independently of the provision of technology.

However, Becker and Ravitz (1999) claim that supportive conditions and the use of technology may cultivate pedagogical beliefs that underlie constructivist practices. In particular, they found that frequent computer and internet use appear to be related to teachers:

- Being more willing to discuss a subject about which they lack expertise and allowing themselves to be taught by students;
- organizing multiple, simultaneous activities during class time;
- assigning complex projects for students;
- giving students greater choice in learning tasks; and
- recognizing the initiative that students can take outside class to do high-quality work.

Other studies have discussed some of the benefits of portable devices, including increased integration into core subjects, better facilitation of project-based learning, as well as enabling students to communicate more effectively (Harris, 2004). In addition, Gulek (2005) claims that after one year in a laptop program, students showed "...significantly higher achievement in nearly all measures" (p.13). While Davies (2004) does not directly discuss student achievement, she found that "the way students learned changed" (p. 39), and "how students went about their learning changed" (p. 39). Students completed work faster and easier, communicated more often, and practiced frequently because mistakes could be easily fixed. With access to a laptop for completing work, they produced more, and a greater range of work, and were more willing to make mistakes, thus giving them more opportunities to learn. The changes in how students worked changed because students were allowed more choice in how they worked (not whether or not they worked), and were able to tailor their learning to meet their needs. Students could pace their own learning and choose from a variety of differentiated resources which were often more relevant and current than the resources they had used in the past.

Another case study from Maine, looked at two classroom teachers, each of whom had different beliefs about the value of technology in their practice (Garthwait & Weller, 2005). One teacher was very tech-savvy and welcomed the laptops into his classroom, using them every chance he got. The other teacher was not comfortable with technology, participated in the laptop project reluctantly, and integrated technology slowly over time. The gap between the two teachers in how they integrated technology shows the degree of technology integration depends more on the teachers' beliefs about technology, and less on access to technology. I will discuss teacher beliefs briefly in the next section.

Teacher Beliefs

There is a large body of research in the area of teacher beliefs about technology and how these beliefs affect pedagogy, however in this research I have used the term 'beliefs' interchangeably with 'perceptions' and 'attitudes' about technology . Other researchers such as Ertmer (1999) do likewise, suggesting, for example, that we need to fully understand the beliefs and attitudes teachers hold about new technologies because they are difficult to overcome. While technical expertise in using software or hardware can be learned relatively easily for most, *beliefs* are "more personal, more deeply ingrained" and harder to change (Ertmer, 1999, p. 51).

In Becker's (1999) study, teachers' perceptions about technology affected both their use of technology and teaching practice. He found that teachers who were using technology (e.g. the internet) in meaningful ways were those teachers who perceived the technology as "valuable" or "essential" to their personal and professional lives (Becker, 1999). These perceptions varied from teacher to teacher in this study depending on the set of beliefs about teaching, technology, and the interpolation of those two elements they held. Their perceptions of what happens in their classrooms when laptops are introduced initially depended on what they believed the impact would be. I was interested in examining how their beliefs changed (or did not) based on what happened over the course of this study.

Conclusion

As wireless, mobile technology becomes more affordable for schools, it is expected that classroom teachers and school administrators will begin bringing more of this type of technology into schools to replace traditional computer labs. Research referenced in this chapter suggests that access to technology when and where it is needed to support the core curriculum (in the classroom), coupled with effective pedagogical approaches can result in positive changes that are not possible in a lab environment. The following chapters will describe the methodological approach of this research where we examine what happens at three sites, with three teachers when mobile technology is introduced in the classroom.

Chapter 3: Research Methods

Purpose

The purpose of this study was to explore teachers' perceptions of the impact of wireless laptops on their teaching and on student learning. The study examined teachers' actions, reactions, comments and reflections as they progressed through the first year where their students had access to laptops in the classroom.

Research Approach

Creswell (2005) describes quantitative research as a type of educational research where the researcher first decides what to study, asks focused, narrow questions, collects numeric data from participants, and then statistically analyzes the numbers. Like this approach's beginnings in scientific research in physical sciences, a quantitative researcher conducts the inquiry in a supposedly unbiased, objective manner and emphasizes the comparison of one group or individual to another. On the other hand, qualitative research is where "the researcher relies on the views of participants, asks broad, general questions, collects data consisting largely of words (or text) from participants, describes and analyses these words for themes, and conducts the inquiry in a subjective, biased manner" (Creswell, 2005, p. 39).

I chose a qualitative approach because in the complex field of education and pedagogy I needed to examine the impacts of the introduction of laptops in a specific context and in a holistic way. "Qualitative researchers deploy a wide range of interconnected interpretative methods, always seeking better ways to make more understandable the worlds of experience that have been studied" (Denzin & Lincoln in Creswell, 2005, p. 43). Data collection for this study involved several methods, including observations, teacher journaling, discussion notes, and a focus group interview. In this chapter I will describe how I used a case study approach to explore the questions posed in this study.

I considered several qualitative research methods for this investigation.

An ethnographic approach is literally 'writing about people' and normally involves the researcher being a participant-observer in the everyday lives of the participants (Somekh & Lewin, 2005). This could have been appropriate since I was studying a group of staff members at schools with the express intent of looking at how this technology affected their culture or beliefs about teaching with technology. However, this study is more focused on exploring how students having access to laptops affects teacher beliefs, and thus their teaching, and not on the interrelationships between the staff.

This study could have taken a narrative research design, since many of the methods fit with the criteria set out by Clandinin and Connelly (in Creswell, 2005, p. 479). However, I see narrative research as fitting more with research questions dealing with personal journeys in education – where stories will best bring the audience into the mind of the subjects of the research to paint a picture of an experience that can shape teaching and learning. While each of the participants in this study certainly had significant personal journeys during this year, this question seems to be more about the case or the situation, and not specifically about the individual teachers, making writing in a narrative format more difficult.

If I were one of the teachers at the school where this project was being initiated, and I was interested in the 'how' of technology integration, I may have chosen to conduct action research as I feel it would have the most immediate impact in encouraging change in the school. Creswell (2005) states that this method is most useful when trying to solve a very specific educational problem. The fact that this method encourages collaboration on projects and pulls together research and practice was appealing. However, this research was more about exploring the impact of the introduction of laptops and less about solving a specific problem.

The design of this study is a multiple case study using qualitative methods. My interest in this topic left me wanting to discover the impact of wireless laptops in the context of teaching and learning and look for congruence with my own pedagogical experiences with technology described in chapter one. In Somekeh & Lewin (2005) Harry Torrance describes the case study method as "...more particular, descriptive, inductive and heuristic than other forms of research. Case studies tell a story of a particular situation, time and place" (p. 34). I wanted to examine what happened at the three sites from the participants' points-of-view – to take an in-depth look at the impact of bringing laptops into these classrooms across a variety of teaching styles and settings. The ability to be particular, to describe the events which took place in a thick and rich manner (Guba & Lincoln in Creswell, 2005), to induce reasons from observation and conversations, and to tell the story of what was a very different year for these teachers and students all influenced my choice of this methodology.

The primary tools of case study research, namely interview and observation, fit well with the questions in a study that deals with teacher perceptions. I also employed classroom observations and asked teachers to keep journals throughout the school year. The focus group interview was semi-structured and allowed for unexpected issues and information to be captured. These data were compared to that collected during observations and from teacher journals and were coded into themes. By observing what happens in the classroom, the perceptions can be compared, validated, and further examined. Another strength of case study is that it can provide a *rich description* (Geertz in Somekh & Lewin, 2005) and this rich description of the cases examined in this study can be contrasted and compared to the other case studies involving classrooms with access to wireless laptops in order to broaden our understanding of the impact this way of using technology has on teaching and learning.

This study: An overview

This research is comprised of three case studies at three different locations. The cases explored in this research have several commonalities. The teachers are all part of a provincially-funded and school district-coordinated pilot project which provides wireless laptop computers to students. For each of these educators, this is their first foray into a world where students have high speed access to the internet and to network applications in their regular classroom as opposed to a computer lab. The qualitative methods used to gather data included a focus group interview, classroom observations, teacher journaling, and notes from informal conversations. These will be discussed in further detail later in the chapter.

To validate the findings, I attempted to meet the criteria described by Creswell (2005), including triangulation and member checking during and after the research process. "Triangulation is the process of corroborating evidence from different individuals, types of data, or methods of data collection in descriptions and themes in qualitative research" (p. 252). In this study, themes emerged from the data when I compared different types of data and methods of data collection. In looking at the evidence from my own observations of how teaching and learning was being impacted in the classroom with both teacher journal entries and their responses in focus group questions, I was able to attest to the accuracy and credibility of my findings. "Member checking is a process in which the researcher asks one or more participants in the study to check the accuracy of the account" (p.252). After the classroom observations I reviewed some of the general ideas from my field notes with the teacher I had just observed. This gave them the opportunity to let me know whether the description was complete and accurate. After the focus group interview, which was audio-recorded and transcribed, I sent a copy of the transcript to each of the three teachers who participated and asked them to review their statements to ensure their statements clearly represented their views and were accurate.

I also had a prolonged, persistent engagement with these teachers and their students beginning in September 2006 and continuing through June 2007. Teachers made journal entries throughout the year (some more regularly than others), observations occurred over the course of six months, and email communication with the participants was regular.

Selection of participants and research sites

There were several teachers who were involved in the *Wireless Mobile Technology* project in this district, all of whom were teaching in a large urban school district. This project provided their schools with funding to establish a wireless networking infrastructure and to partially fund the purchase of a class set of laptop computers. Schools submitted applications to participate in this project and teachers volunteered to participate by using the laptops in their classes, by attending professional development

sessions, participating in an online community, and being open to have me observe their classes on occasion.

All participants were made aware of the purpose of the research when they signed the *Participant Consent form* (Appendix A), and also reminded at the start of the focus group interview. This purpose statement appears in the first paragraph of the cover letter which accompanied the Participant Consent Form. Of the teachers involved in the project, I provided seven with the consent form and all agreed to participate in the research for this thesis. My experience with all seven participants in professional development and planning events related to the district project allowed me to have some indication of their teaching style and experience. The three primary participants were selected because they represented different pedagogical approaches, genders, experience levels, and grade levels specialties. Peripheral data from the other teachers involved in the project was collected in the form of notes from informal conversations and journal entries posted to the online journal.

Of the three primary subjects in this study, two are elementary school generalists and one is a junior high science teacher. Detailed descriptions of the participants and setting can be found in chapter four. In general, purposeful sampling was used to select the participants; specifically I used a maximal variation strategy to attempt to explore the complexity of what was happening in classrooms (Creswell, 2005). Of the seven participants in the study, I could have chosen all tech-savvy males, for example, or all teachers who used a constructivist approach. Instead I chose two females and one male, two elementary generalists and one subject-area specialist, two with admittedly didactic approaches to teaching and one whose style leaned towards a constructivist approach. One thing these three had in common was that they had between five and twelve years of teaching experience, so there were neither grizzled veterans nor inexperienced teachers in the sample.

Role of the Researcher

As a technology project manager in my school district, I manage several initiatives. While many of these involve working with various central departments, principals, teachers, and computer technicians, I am not in a direct position of authority over any of these individuals. The projects require that I set goals, provide timelines and budgets, plan and facilitate professional development, and gather feedback from the school participants. School principals have asked their staff to participate in these projects and have expectations for them to take part in any of the feedback activities. I asked (and received) permission from the participants to use this feedback as data for my thesis research.

The application process for the laptop project was competitive. For those that were successful, it meant a significant amount of technology supplied to their school via the grant for which I was ultimately responsible. Participants at the schools may have felt the need to report positive findings because of my role in their school receiving this

grant. I counteracted this by trying to develop collegial relationships with these teachers through the course of the year, always letting them know that the significance of the project lay in the accurate reflections of how technology was being integrated into their teaching and student learning, if at all.

I am aware of my bias and of the lens through which I see the role of technology in this study. This lens through which I see the role of technology in the classroom is therefore often rose-colored. My bias comes from my experiences in teaching with technology, and from my role as the laptop project manager. As a teacher I noticed that students using technology when and where they needed to use it were more engaged and motivated in their work. In my role as project manager, I try to help with the successful implementation of wireless mobile technologies in the classroom, including providing advice to teachers, suggesting activities, managing technical issues on a district level, and building connections across the district and beyond. A successful implementation – where integrating wireless mobile technology into these classrooms enhances student achievement and empowers educators – is one of my professional goals. My goals as a researcher are different: To explore teachers' perceptions of the impact of wireless, mobile computing on teaching and learning.

Data Collection

The four primary techniques used for data collection in this study included the following: (1) conducting classroom observations in each of the three primary subjects' schools, (2) collecting teacher journal entries from all participants using a secure, online website (Appendix B), (3) collecting my own notes from informal discussions with teachers (validated through member checks), and (4) conducting one focus group interview involving the three primary participants.

Classroom observations

One drawback to this technique is that anytime there is an observer in the classroom who is an "outsider", atypical behaviours may occur (Hammersly & Atkinson, 1995 in Creswell, 2005). In my experience as a University facilitator for example, I recall pre-service teachers' admissions that having me in the room observing their lessons not only made them anxious and caused them to alter how they handled themselves, but also how the student reactions changed as well. I attempted to alleviate this to some extent by developing a casual rapport with the teachers and the students. In my role with the *Wireless Mobile Technology Project* I had been in these classes several times and felt I had a comfortable relationship with the teachers. I also felt that I had been around these schools enough in the planning stages of the project that the students were almost indifferent to my presence.

I observed three class sessions in each of the elementary classrooms, each approximately fifty minutes in length. Observing a complete class from start to finish allowed me to see the physical process of dealing with distributing the equipment, as

well as the pedagogy. Observations were conducted in January, March, and May 2007. This fits with Creswell's (2005) advice to conduct multiple observations over time. I was able to observe a variety of subjects being taught during these observations, unlike the Junior High, where the teacher was a science specialist. I observed two of her science classes during the research period (one in January 2007, and one in March 2007). Some examples of observable behaviours included: (1) describing the tasks assigned by the teacher, (2) identifying how the teacher is supporting the students who are using the technology, and (3) generally describing the classroom environment.

I used my tablet PC to record field notes using a combination of keystrokes to quickly insert the exact time when I recorded a new observation. I would record the notes in one column under the heading "observations", and later I would fill in the corresponding column, where I recorded my reflections or interpretations of what was happening.

Teacher Journaling

Teachers' online journals were a valuable source of data because they provided an ongoing diarisation of significant events as they unfolded throughout the research. Another advantage of this type of journaling (over interviews) is that when compared to a verbal response, teachers could return to and edit a journal entry they had made. Each teacher was asked to make journal entries intermittently through the course of the research (October 2006 through June 2007). They were encouraged to record whatever they felt was important to contribute, although on some occasions I did send question prompts. (For example, on November 28, 2006, I sent a question to all participants, asking "What is working well and what would you do differently?") Teachers could keep their journal entries in any format they chose, but were encouraged to post their journal online using the project website. In order to post entries, participants are required to log in to a secure server which is only accessible to project participants. Teachers were made aware that their online journal entries were not anonymous, which may have been one reason why there were few entries through the course of the research.

Notes from informal discussions

I also collected data from informal conversations with teachers which were validated through member checks. While the advantages of online teacher journaling (already transcribed, easily editable) was *my* preferred collection method, I quickly realized that for these busy teachers logging in to a website, no matter how easy I made the process, took valuable time and in many cases did not happen. Informal discussions, the kind that took place after a classroom observations when the teacher has a few minutes before the next class comes in, or in the staffroom over lunch hour, were incredibly valuable as this was also when they had a chance to catch their breath and reflect (even if just for a moment) on how the introduction of wireless laptops was having an impact on teaching and learning. I would record notes from these

conversations using my tablet PC. This way, all of my notes (from classroom observations and conversations) were completely digital and searchable.

Interview

The three primary participants participated in a focus group interview in late May, 2007. I conducted a semi-structured interview in a private meeting room in the district's central office building. The interview lasted just over one hour, and was audio recorded using *Microsoft OneNote* software and my tablet PC and later transcribed. The four of us sat around a small table in an informal setting, and I asked open-ended questions in order to allow the participants to voice their experiences without the constraints of my perspectives or of past research findings (Creswell, 2005, p. 214). Examples of questions posed during the focus group meeting included:

- How did you feel about the laptop project when it was first announced that your school (and you) would be involved? How do you feel now?
- Did the integration of portable computing devices change your teaching practice? If so, how did it change it?
- Did the integration of portable computing devices have an impact on student learning in your classroom?
- What changes did you notice in the teaching and learning environment after the introduction of portable computers?

While these questions were sent to interview participants in advance in order to give them an opportunity to reflect and prepare, I also encouraged open discussion during the interview by asking probing questions which emerged during the process. The audio files from the focus group interview were transcribed, and the notes from the eight classroom observations and informal discussions with teachers were digitally compiled and included with teacher's entries to the online journaling website.

Data Analysis

Creswell (2005) describes six steps in collecting and analyzing qualitative data such as those collected in this study, including: "...preparing and organizing the data, exploring and coding the database, describing findings and forming themes, representing and reporting findings, interpreting the meaning of the findings, and validating the accuracy of the findings"(p. 230). These steps were helpful in organizing and making sense of the data collected in this study, and will be detailed below.

Preparing and organizing the data

I organized all of the data by type (e.g. observation, journal entry, notes, transcribed interview) using the *OneNote®* software on my tablet PC. OneNote allowed me to create a 'notebook' for the research, and several 'notebook sections' for the data from various sources. This was an invaluable tool in organizing data since not only did it automatically save every keystroke entered, but it could be automatically set to back up my data to a secure external storage device daily. *OneNote®* software and a tablet PC had several advantages for collecting data. First of all, the tablet PC allowed me to enter text using a stylus as opposed to keyboarding, allowing me to fold down the screen of my tablet (a feature not available with a regular laptop) and write on it as if I was writing on a pad of paper. This was less intrusive when speaking with teachers or during the focus group interview as it was simply taking digital notes. These notes can be converted to type using the *OneNote®* software, thus eliminating the need for further transcription. In addition, when taking notes, it was very easy to insert space into a page or link to another similar idea from another data source.

The real value of the tablet PC and *OneNote®* software came in the focus group interview and transcription. OneNote software has an inherent audio recording capability that, during playback, marks the text or notations made when the audio was recorded with the corresponding text. So, for example, when Rick said something about 'assistive technology' during the focus group interview, I wrote "assistive tech" in *OneNote®* using my stylus. Later, when transcribing, I could click on my writing of "assistive tech'" and it would play the audio recording of Rick talking about it. Compare this method to using an analog audio cassette tape or digital audio recorder. This made it very easy to transcribe the focus group interview, and made going back to review what was said by the interview participants a very simple process.

Exploring and coding the database

After the focus group interview was completed at the end of May 2006, I had completed data collection. I now had several pages of journal entries from the online journal site, notes from my informal conversations with participants, notes from classroom observations, and a transcription of the interview. I read the data from start to finish three times, making margin notes and trying to get an overall sense of the data, following the advice of (Agar in Creswell, 2005), who suggests you "...read the transcripts in their entirety several times. Immerse yourself in the details, trying to get a sense of the interview as a whole before breaking it into parts"(p. 237).

I next began to code the data. Again, this is where the *OneNote®* software became invaluable. I began with themes that I had emerged from the data on the preceding readings, then used multiple highlight colors and reviewed the data again, attempting to code all data and classify into one of the categories. As data appeared which did not fit into an existing category, I created new categories. I also added more detail under each

category heading. I then reduced the list of codes to a manageable number, separating those dealing with teacher perceptions of the impact on their teaching, and those dealing with the impact on student learning. I reviewed the data several times, until the data was either coded or was deemed superfluous to this research.

Describing findings and forming themes

After creating an initial list of nineteen codes, I began thinking about the broad themes that might begin to answer the main research questions in this study, which were:

- What happens in a teaching and learning environment that makes use of laptop computers; and
- What are teachers' perceptions of the influence this technology has on their teaching AND on student learning?

I was able to group, summarize and arrive at six major themes, with sub-themes for each that detail the findings (Creswell, 2005). These will be presented in chapter four. After several reviews of the data I felt that I had identified all of the major themes and that no new information could add to my list of themes or to the detail of existing themes. Reducing the number of themes to six allowed me to write detailed information about a small number of themes, rather than be repetitive, or write general information about a large number of themes.

Validating the accuracy of the findings

Themes were later combined, refined and reviewed in person with the primary participants for verification. In addition I separated each primary participant's data and sent them the text file via electronic mail for validation, requesting they add, delete, or clarify any statement they felt required such action. By taking the findings back to the participants in the study to check the accuracy I was validating the data through "member checking" (Creswell, 2005, p. 252).

Limitations and delimitations of the research

Limitations

As with all qualitative research, there are limits to the generalizability of the findings of this research (Creswell, 2005). This study aimed to deeply explore what was happening in the three project sites and not what was happening with technology integration in general. However, by providing deep and rich descriptions of these cases readers should be able to draw comparisons to their own situations and determine how

these findings relate to their own contexts. More specifically, several research limitations were inherent to the study:

- My role as the project lead for the school district's *Wireless Mobile Technology Project* was also a limitation. In this role I solicited applications from schools for a provincial grant, selected schools to participate, provided funds to the schools, and lead professional development sessions for staff. The success or failure of the project hinged on how the introduction of laptop computers impacted teaching, learning, and achievement. My role as a researcher was to explore and report what happened, with any notion of "success" being irrelevant. While I made several accommodations to mitigate how my role might influence how teachers responded in data collection activities (detailed in chapter two), an external researcher might have had different findings.

- My position at the school district level may have impacted the involvement and responses of participants, and possibly resulted in an overly favourable portrayal of elements of the study.

- While all participants had access to the online community where they could submit journal entries, they were not provided with time to make these entries. As a result, there were few entries from several of the participants. The bulk of the online journal entries came from one of the participants (Rick), with very little data coming from any of the other six participants. (The three primary participants, plus others who agreed to participate in the research, but who were not selected for classroom observations or focus group interviews, all wrote at least one journal entry.)

- The subjects selected for classroom observations and the focus group interview were not randomly selected. These teachers were selected because, based on conversations during professional development events that preceded the research, they demonstrated and articulated their preferred teaching style. They were chosen because they represented a variety of pedagogical styles, genders, and grade levels taught. This purposeful selection was important because I wanted to be able to describe teacher perceptions of the impact of laptops in a variety of settings and among differing teaching styles. My limited experience with these teachers gave me enough insight to make these selections. However, this is a limitation because my selection of the participants was based on only my perceptions of their pedagogical styles from preliminary conversations. While I could be sure that I was selecting a variety of genders and grade levels taught, my purposeful selection based on pedagogical style was anything but sure.

Delimitations

The following delimitations were intentionally implemented due to the nature of the study and the resources available to conduct the research:

- To limit the scope of the research I examined the phenomena solely from the perspective of the teachers, focusing on their perceptions of how teaching and learning changed as a result of introducing portable computers into their classrooms. The perceptions of students, administrators, and parents would also have been valuable, but were beyond the time and resources I had available to do this research. Narrowing it to just the teachers made the study manageable for me.

- There were several other teachers using the laptop carts in two of the three sites, but in order to keep the scope of this research at a manageable level, I chose three teachers (one from each project school) for this multi-case study.

- I have easy access to these sites. These sites were convenient because they were each part of the *Wireless Mobile Technology* project which I was leading, and were also the only three sites where class-sets of laptops carts were being introduced at the same time as this study.

Assumptions

I believe it is important to explicitly state my assumptions and personal beliefs about teaching and learning in order to properly frame this thesis. While I do not believe that technology is a panacea for all that ills education, I do believe that a variety of technologies, when used in the right circumstances, can motivate students, address differentiated needs, and provide opportunities to engage them in the curriculum in ways that are not possible without it.

Technology can be particularly effective in addressing student-centered learning. This is identified in the literature as essential in order to learn with technology (Papert, 1993). In my view a student-centered classroom is one where students have choices in how they will approach their learning (within the bounds of the curriculum), and I believe this leads to more student engagement. A student-centered environment results in the learner having more control. This resulting learner control means that teachers are less prescriptive and are more flexible both in their pedagogical strategies and in the types of products they expect from their students. I believe that in many cases, student-centered learning, where students are provided with the tools and flexibility to explore multiple ways to engage in their own learning, is preferable to

teacher-centered learning. Teachers will design and develop learning activities, and then work with students to help them achieve their learning goals.

The role of technology in education is to effect whole learning environments by providing the opportunity for knowledge construction and for the communication between learners to build on distributed knowledge (Salomon, 1998). Students have grown up with access to multiple technologies, mostly used for play. If students are to use computers as tools to solve problems, they need access both when and where they need it.

Chapter 4: Findings and Discussion

Overview

This chapter provides data collected about, and discusses teachers' perceptions of what happens to a teaching and learning environment that introduces laptop computers. Specifically, I explored the teachers' perceptions of the influence this technology had on their teaching as well as on student learning. The methods of data collection included: (1) conducting a focus group interview with each of the three participating teachers, (2) three classroom observations at each of the participating teachers' classrooms, (3) collecting participating teachers' reflections via a secure, internal, online journal used for a district pilot project described in the previous chapter, and (4) notes from informal discussions with teachers. This chapter describes and discusses the research findings relative to the original research questions presented in chapter one: *What influence does wireless mobile technology have on teaching and learning?*

This thesis discusses both the *Wireless Mobile Technology (WMT)* project, and this research. My role in the project was to plan for the implementation of wireless technologies, coordinate a community of practice, and facilitate professional development sessions. All teachers involved in the project (including those who volunteered for this research) participated in at least four sessions where the topics included the needs of 21st century learners, research syntheses of mobile computing studies, and planning for the integration of technology. Teachers were encouraged to continue to collaborate and share materials online using the website developed for the project, as well as post journal entries.

In this chapter I will be examining three research schools and the teacher participants at each site. I will first provide descriptions of the neighborhoods, schools, teachers, and students, and then describe how these teachers have used technology (or not) for their teaching in the past. Several themes emerged from the research, and these will be identified, described and discussed in the remainder of the chapter.

Description of Sites and Participants

The schools participating in this study are all part of a large, urban school district with 197 schools, over 79,000 students, and over 10,000 employees. The district's philosophy emphasizes "choice" and uses a site-based management model combined with an "open boundaries" approach. This means that schools each receive an allocation from the school board, and each then determines how to spend that money based on the priorities established by the school. The introduction of this model

coincided with the introduction of technology in schools over twenty years ago, and has resulted in a disparate allocation of technology resources throughout the district.

Despite these disparities, all schools in this district are connected to Alberta's SuperNet, a high-capacity network that connects schools, hospitals, libraries, and government (Alberta Education, 2007). The school district chose Aruba Networks for their wireless hardware because of its scalability (it is used on large campuses such as the University of Calgary and Ohio State University), its robust security features, and the ability to automatically load-balance bandwidth over multiple access points. This was an enterprise-level solution which was very reliable and secure throughout the duration of the project. This school district has centralized technical support, meaning that there are roughly forty technical analysts supporting the 197 schools. All of the schools involved in this research employ one of these district technicians for a scheduled amount of time per week, with the remainder of their time spent at other district schools.

Prior to the delivery and installation of the mobile lab of thirty laptop computers, each project school held a meeting with district technology staff (including myself as project manager) to discuss their hardware and software requirements. The three schools were located in areas of the city with varying demographics. The three schools were Lane Way elementary, River Glen elementary, and Forest Park junior high school.

Table 1. Demographic comparison of school neighborhoods (City of Edmonton, 2007)

Neighbourhood	Average Income	Education Attainment (University level)	Transiency (people who moved during last year)	Lone parent families
River Glen	$115,563	53.7%	11.8%	12.4%
Lane Way	$46,777	12.2%	24.1%	26%
Forest Park	$94,786	41%	7.5%	3.9%
City Average	*$66,412*	*27.1%*	*19.4%*	*18.4%*

Site #1 – Grade six class, River Glen Elementary

School description

River Glen school is a picturesque school house set near the heart of the city in one of this city's most affluent and well-educated areas (City of Edmonton, 2007). Originally built in 1940, it is at capacity (185 students) with children from the surrounding neighborhood and employs nine full-time teachers. The district requires each school to have an 'instructional focus' which they use to frame their school goals and priorities. For example, other schools in the district may focus upon literacy, numeracy, or higher-order thinking skills. River Glen has an instructional focus on 'assessment-for-learning'

and the hallways and classroom walls are papered with examples of students evaluating their own, and others' work using small paper notes, self-developed rubrics, and checklists. The days when I was on site, there were always several parents present, helping with bulletin boards, library tasks, and generally helping out where needed. The school has both a French and Art specialist and they offer these subjects to all grades. Extra-curricular activities include clubs of chess, track , and choral music . The beautiful library area is the focal point of this school. Built in what was once the auditorium, its twenty-foot ceilings and large windows make it a wonderful collaborative space.

Prior to this project, the school had a small, cramped computer lab at the back of the library on what was formerly the stage of the school auditorium in this historic school building. The computers were donated, second-hand, desktops, and were neither overly reliable nor frequently used. Prior to the beginning of the 2006-2007 school year, this school acquired a mobile lab of thirty laptops which were reserved by teachers as needed and delivered to the classrooms by a group of students working alongside teachers (River Glen called this their *SWAT Team*). These students also helped to facilitate the routines of getting the lab up and running, such as helping with distribution and troubleshooting simple start-up issues.

River Glen Elementary had installed a new network switch, a wireless switch, and four access points (AP's) at the start of the project. Funding for this hardware came from Casino revenues and from a grant from Alberta Education for the WMT project. River Glen had a technician who was assigned to the school for one afternoon every two weeks. As with other schools in the project (and most in the district), all technical support issues were reported electronically through an online service request, and dealt with by this technician. The technicians were supported by others at the district's central technology department including several network analysts and senior technicians. Early in the school year there were several problems with connectivity at the school, which resulted in students either experiencing long delays in logging in, or simply not being able to log into the laptops all together. The majority of these issues were resolved by the middle of November 2006.

Teacher description

The teacher, Laura Smith, has eleven years of teaching experience and has been at this school for four years. She was the principal teacher of this grade six class for all subject areas except physical education. In addition, for two periods a week another teacher takes Laura's class to teach them "computers" (her description). Prior to this year, she rarely used technology of any form in her teaching and was a self-described "newbie" when it came to using technology. Using the ACOT continuum, she was using technology at the 'adoption' stage. In the past, she used her desktop computer in her classroom for management tasks such as email and using the district's electronic grade book. She cites the poor condition of the computers, as well as the cramped quarters in the lab, as reasons for not planning more activities that integrated technology. Many

students would take their work home to use word-processing or presentation software in completing assigned work.

Laura focused on assessment for learning strategies and used a project-based, interdisciplinary approach with her students. For example, while she asked students to conduct research and prepare a report (in 'PowerPoint') on 'trees and forests' for science, she also incorporated language arts assessments into the criteria for the project, and worked with the school art teacher to incorporate student work into the unit. Reports from research suggest that this is the pedagogical style that is very well-suited to effectively integrating mobile computing (Garthwait & Weller, 2005; Harris, 2004; Judson, 2006).

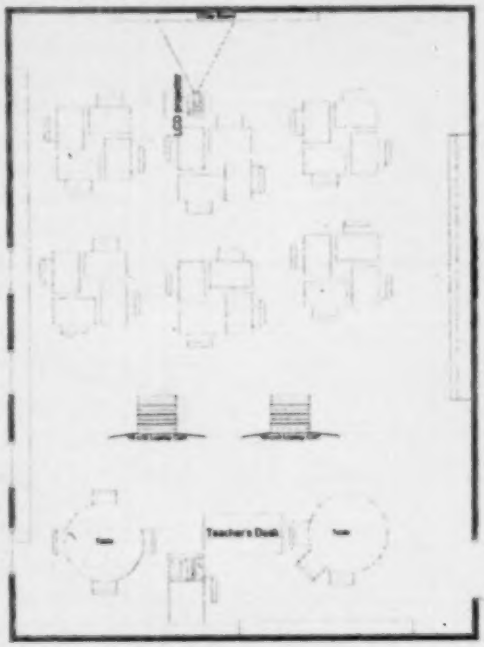

Figure 1: Laura's River Glen classroom layout.

Laura's classroom, like many elementary school rooms, was papered with rubrics, outlines, strategies, and tools students could use to help them with organization, planning and project work. Desks were typically arranged in some sort of group format – during two visits student desks were arranged in groups of four, with all students facing the center. Laura's desk was at the back of the room, near the one entrance door, and there was a large table at the back as well where she often held conferences with individual students.

Student description

The class at River Glen had twenty-seven grade six students in the first year of an International Baccalaureate program, which is interdisciplinary and emphasizes project-based learning. The majority of these students were from the surrounding neighbourhood, and many had been going to school together since kindergarten. With the focus on assessment-for-learning in the school, these students had a lot of experience with cross-grade work, and there was a supportive attitude among students. All students in this class spoke English as their primary language, and there was one student coded with autism who had been assigned an aid. Students typically used the laptops about four to six hours per week. The teacher reports that all of her students had access to a computer and the internet at home.

Teacher's use of technology

Laura, and the rest of the River Glen staff purposely kept the number of software programs installed on the student laptops to a minimum. They preferred to focus on the applications that most teachers were familiar with in order to "ease into" the integration of technology. From journal entries at the end of the year it was evident that this was an effective strategy in getting a faculty who rarely used technology the year before, to regularly infuse technology into teaching and learning during this school year. Teachers did not feel that they were in over their heads and the limited applications on the laptops kept technical issues at a minimum. All laptops in their mobile lab had the *Microsoft Office®* suite including a web browser, *Google Earth®*, as well as basic photo and video editing programs which come as part of *Windows XP Professional®*. *Google Earth®* is an interactive three-dimensional atlas which allows users to explore satellite images of the earth, overlaid on a spherical model that creates the illusion that you are flying over the earth. Teachers from River Glen reported using this software in Social Studies and Science to explore different areas of the globe and to report findings.

Site #2 – Grade 5 and 6 combined class, Lane Way Elementary

School description

Lane Way elementary school, built in the 1950's, is a bright and meticulously maintained two-story school building, situated in a neighborhood of the city with incomes and education levels far below the city average, and with a high percentage of single-parent families (City of Edmonton, 2007). With a population around 150 students and nine full-time teachers, the school is a district site for students with behavioural disorders and has an instructional focus on literacy. It has a hot lunch and morning milk program to support many of the students from low-income families who might otherwise not eat a proper meal during the day. In contrast with River Glen elementary, I did not see parent-volunteers in the school during any of my school visits.

Before receiving grant funding to purchase a laptop for every student in the grade five and six combined class, Lane Way had one computer lab for its students, housing donated desktop computers. Funding for this hardware came from casino revenues and from a grant from Alberta Education for the WMT project. Teachers described the performance of the network and these computers as 'spotty, but okay', the room as very uncomfortable (especially hot during May and June), and the overall use of technology in their classes as an afterthought.

This school also had a district technician assigned to them for one half-day per week, which is the norm for a school this size, but probably not adequate for a school

with a one-to-one laptop program. Early technical issues with connectivity (at all three schools) resulted in a lot more time required at each school in the early part of the school year, but this waned as the issues were resolved, and by November the half-day per week usually covered any technical issues that arose.

Teacher description

Rick had been teaching for nearly five years and began the year as the most computer-savvy of the three teachers in this project. Rick had been a member of the district team that helped coach other teachers in the use of technology and in this role provided several in-services both inside and outside of his school. Despite his relatively short tenure as a teacher, he is a leader in this small school and is seen as a colleague to provide professional development on many fronts. Early in the school year Rick indicated his eagerness to try and use technology in a number of different ways with his class. According to the ACOT continuum, Rick would have been somewhere between the 'adoption' and 'adaptation' stage at the start of the project. He had used technology extensively in past years in almost every subject to support traditional modes of instruction, and even by the first observation he was using many of the productivity tools with his students, often in combination.

Rick used a didactic, teacher-centered approach in his teaching, and in the classes I observed, the students were always very quiet and on-task. Early in the school year, I observed the students working individually at their desks, facing the front of the class. He indicated his eagerness to try and use technology in every subject area, if possible. The desks in his classroom were always arranged in single rows, facing the same direction. During observations late in the year, students were still working individually, but were allowed to sit where they liked in the classroom, including under tables, at a large table at the back of the class, and in the hallway. His desk was at the back of the classroom, opposite the door, and he too had a large round table for conferencing with students next to his desk. Prior to the school year, Rick had a LCD projector mounted in his classroom and connected to his

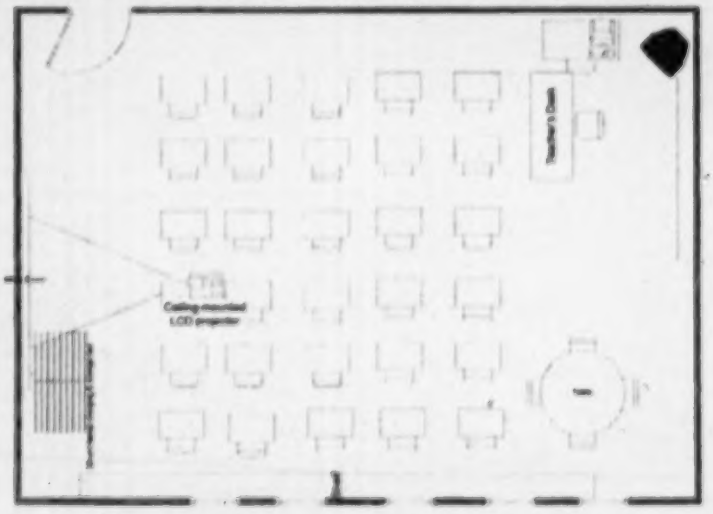

Figure 2: Rick's Lane Way classroom layout.

teacher workstation.

Student description

The class involved in the study is a group which includes grade five and six students, with each of the thirty-one students in this group having one-to-one access to a laptop computer, meaning they each were assigned a laptop for their exclusive use at home and at school. It should be noted that this is quite a different scenario from the other two sites, where all students shared access to mobile carts of laptops. Ninety percent (27 out of 30) of the students in the Lane Way class had internet access at home prior to this project (Korte, 2007). Those students who did not have access were provided with a dial-up internet account from the school district for the duration of the project. Rick had one ESL student in this class of thirty students.

Teacher's use of the technology

Their laptop configuration was nearly identical to that at River Glen (described above), except they added more software, including a sky-science multimedia program called *Stellarium*®, a concept-mapping program (*Kidspiration*®), and text-to-speech software (*ReadPlease*®). *Stellarium*® is similar to *Google Earth*® described above, but instead of looking down at the earth from space, this software simulates looking up into the sky from anywhere on earth. Users can choose from several categories and levels of labeling which display constellations, planets, the movement on celestial bodies over time, and much more. Students used this software in their Science classes and were observed alternating back and forth between this software and *PowerPoint*, cutting and pasting screenshots into their presentations.

Kidspiration® is a concept-mapping software program targeted specifically for children. It includes numerous templates related to all of the main subject areas (e.g. story outlines, process map, etc.) as well as reams of clip-art for students to use in creating their maps. Rick used this software extensively with his class in planning for writing in language arts, as well as for creating mind maps in other subjects.

ReadPlease® software converts text on the screen to audible text. Students at Lane Way used this free software extensively to review their own writing, and to assist them in reading online text. This was especially helpful for those students who had difficulty reading. Rick would often assign reading online to students, which allowed them to use this software to help them understand the text.

In addition, since these laptops were going home with the students on a daily basis, students were permitted to personalize some features of the desktop, including adding their own wallpaper, screensaver, color scheme, and other features.

Rick's use of technology for teaching differed significantly from the other teachers in this study because his students had exclusive access to their laptops at school and at

home. In past years, Rick had used the school's computer lab extensively since not many of the other teachers at Lane Way were using it and because it was directly across the hall from his classroom. He estimated that his students used the lab for writing, making presentations, or conducting internet research, several times per week.

Site #3 – Jr. High Science, Forest Park JHS

School description

Forest Park is one of the districts' newer junior high schools and is located in an affluent and well-educated suburb of the city (City of Edmonton, 2007). As you walk in through the front doors, the large student atrium greets you with its vaulted ceilings and large windows facing the south. It is full to capacity with students from the surrounding neighborhood, is always bustling and crowded, and has many active clubs and teams. The forty-five desktop computers in the lab and library were shared between the nearly 675 students and 44 teachers on site. This school added a mobile lab of thirty-two laptop computers in order to increase student access to technology without infringing on the already very limited space available in the school.

The school project team's instructional focus is differentiated instruction, and their stated goal in the project was to collaboratively plan science activities which utilized the laptops, in order to better address a variety of learning styles and abilities. The science classes observed were forty-seven minutes in duration, and had between seventeen and twenty-five students in either grade eight or nine. Since this school's project involved only the science department, I only observed science classes. Their phased implementation plan included using the laptops during the project's first year exclusively with this department. These teachers were to develop protocols and promising practices for using the laptops in classes, with the prospect of adding more mobile labs to other subject areas in subsequent years. Implementing the project this way was also a way to have every student use this technology, as every student in the school would take science at some time during the year.

Forest Park also employed a district computer technician who was scheduled to work with the school one half-day per week. The software image on their laptop was also similar to the basic image described above for River Glen. The teachers relied heavily on internet-based learning objects, such as those available through Alberta Education's website, as well as other online resources from *United Streaming*® and *BrainPop*®. These products provide online learning objects ranging from simple video clips to interactive learning objects. Some of the resources on the Alberta Education website were more advanced simulations, but for the most part the Science teachers at Forest Park school used the simple simulations freely available on the internet. *United Streaming*® is a repository of online videos and other resources which have been

licensed for use in school, and matched to Alberta curriculum. *BrainPop®* is a pay-for-access website which includes short, snappy cartoon lessons on a wide variety of topics, usually followed by a multiple-choice 'pop-quiz' on a few of the main facts from the segment. With all classrooms in the school having monitors connected to the teachers' computers, these resources were used by most staff at one point or another during the school year.

Teacher description

Carly Douglas taught grade seven and nine science and had been a teacher for ten years when the school year began. She taught at several junior high schools and worked closely with the other teachers in her department in planning lessons and units. The science department at Forest Park shared this mobile lab among five teachers, with the rest of the school relying on the library and lab computers. Her self-described pedagogical style is to give the students the resources they need to solve the big questions she poses, and have them use a variety of strategies to solve the problems based on their individual learning styles. This fits with their school's instructional focus on differentiated instruction, and also with the reported strengths of wireless, mobile technology in facilitating the learning needs of individual students (Harris, 2004).

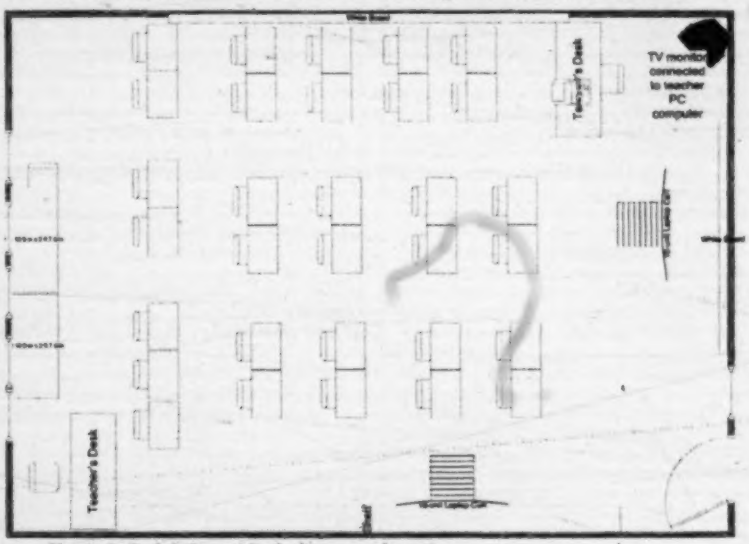

Figure 3: Carly's Forest Park classroom layout.

The desks in Carly's classroom were always arranged in pairs, facing the same direction, with a few desks in groups of three. During all observations, students worked independently on their laptops, but working together and helping each other was common. Carly was never in her desk, and moved about the classroom constantly. She also had a television monitor connected to her desktop computer at the front of the class.

Student description

As mentioned earlier, at this junior high school the laptops were being shared among the science department of the school. I observed two different classes at Forest Park, as Carly's timetable included six different groups of students. The classes I observed had a nearly equal number of males and females, with the grade seven class having twenty-seven students, and the grade nine class seventeen. The teacher reports that all students have access to a computer and the internet at home.

Teacher's use of technology

Carly described how she used technology in previous years during a de-briefing session which followed one of the class observations:

> I didn't use a computer much for teaching in the past. I was more of a hands-on person who would bring in the stuff and show them instead of going to the online stuff. I mean we have my computer hooked up to the TV in the classroom, but it's not the same. You know I'd rather bring in a watermelon and smash it on the floor to show them the idea of physical change, but laptops meant it was different for me...but it's coming...it's good, but it's a huge learning curve.

Other staff at this school also complained about the lack of access to technology, since there was only one computer lab that could be booked for classes. For this reason Carly, like many other Forest Park teachers, rarely integrated technology into any part of their classes in previous years. For this reason, she would have been firmly in the 'adoption' stage described in the ACOT study.

Early in the school year, when both Carly and her students were just getting used to the idea of regular access to technology in the classroom, students were using the laptops primarily to conduct peripheral research using the internet. For example, students were introduced to the 'space'unit with a short video clip, provided some oral feedback to the teacher, then opened a document from a shared network folder which included a written description of the day's task (Carly had reviewed the task orally earlier) as well as hyperlinks to the websites they were to use as reference. They were not using the laptops to record any data; they were simply looking up information and recording it on paper graphic organizers which had been distributed earlier. In this sense, they were simply using the laptops and the website as replacements for textbooks and other reference materials.

Overview of themes emerging from the research

Data from the focus group interview, classroom observations, online journals, and from informal discussions with participants were compiled as described in chapter three. A summary of the five themes which emerged from the research is shown below, then described and discussed in the following sections.

Teacher perceptions of the impact wireless mobile technology had on their teaching and on student learning:

- **Change in beliefs lead to a change in actions**
  - Teachers' beliefs about the effectiveness of technology changed.
  - Access to reliable laptops lead to increased integration of several types of technology.
- **Shift towards a more student-centered approach.**
  - Teachers were willing to give up control
  - Students were more willing to collaborate with other students and their teachers
- **Changing classroom environment**
  - Teachers found assessment was easier and were more aware of student progress at any given time.
  - Teachers relied more on collaboration in their planning
  - Work load was not heavier, just different.
  - Classroom management became easier with more on-task behaviour.
- **Increased Student engagement and pride**
  - The quantity and quality of student writing improved.
  - Students were engaged by the technology; enjoyed using the laptops.
  - Students were proud of their work and wanted to show it off.
- ***Other***
  - Students did not have a common set of technology skills.

Change in beliefs, change in actions

Teachers' beliefs about the effectiveness of technology changed

Each of the three teachers came to this project with different comfort levels, and experience with technology. Rick reported that he and his class used the nearby computer lab extensively in the previous year and in almost every subject area, while Carly and Laura stated they rarely integrated technology into any of their subjects in the past. For Carly, there was simply not enough access to technology to make planning for it worthwhile. She remarked, "If I didn't have the laptops, I would take the kids up to the lab once a month to do my ICT, and that would be teaching like I used to." For her, it was simpler to keep her students engaged in their work in the classroom than to occasionally march her whole class up to the school's one computer lab during the forty-seven minutes they had for a class. For Laura at River Glen, the cramped quarters in the lab and unreliable technology kept her out of the lab most days. For a teacher who focuses a lot on peer assessment and collaboration, she could not see a benefit in crowding into the small lab simply to write or do research, and saw no other potential uses of technology in her classes. Of the three teachers, it was clear that Rick had the most access to technology, and also took advantage of that access by using it with his class on a regular basis.

The Perceptual Control Theory (Zhao & Cziko, 2001) suggests that teachers' 'perceived effectiveness' of technology – not necessarily its actual effectiveness – plays a role in their decisions about technology integration. If a teacher feels that the cost in time, frustration, management issues (and other factors) outweighs the benefits, they will not use it. Carly's and Laura's comments support this as they described the hassles they felt in moving their classes to the computer lab. The headaches they encountered were stated as reasons why they did not integrate technology in the past, and is supported by the experiences of teachers in other studies (Bauer & Kenton, 2005; Penuel, 2006).

However, as the year progressed, all three teachers reported seeing benefits in using laptops with their students, which in turn lead them to look for more opportunities to integrate other technologies in addition to the laptops. Participants reported that they were able to connect with their students in new and different ways and that these connections were changing not only how they came to view the place of technology in teaching and learning, but was also changing how they perceived their roles as teachers. Carly stated, "This is the future of teaching, we owe it to these kids, and it's what they expect...", and "...after teaching the same subject at the same school for a lot of years, it's like I can do something new, and it's like a new job again. That's exciting." Bringing the laptops into the classes removed some of the barriers each had described when discussing past experiences with integrating technology. For Laura it meant that she could continue to teach in a familiar, comfortable teaching environment,

while for Carly, it was all about access. With regular access to the laptops, she could incorporate technology more fluently into her regular classroom practice.

Over the course of the year, Carly and Laura changed their perceptions of the role of technology and this significantly impacted how they planned and taught their curriculum. They described positive effects on their own personal motivation, student engagement, and achievement as factors that influenced their willingness to integrate technology more. They felt the time it took planning new ways to integrate technology was offset by the time they saved *using* technology for teaching, . Each of them saw the planning they were doing as a worthwhile investment for future years when they would be using these methods and resources again. This added to what I felt was a sense of obligation these teachers had to the students; the access to technology was something students expected and that it was needed to be successful.

Rick, on the other hand, had used his school's computer lab with his students frequently over the past few years and came into this year with big expectations for technology integration. His experience this year was not as exploratory as Carly's or Laura's, but instead was more an expanding of his beliefs to fit with his now 'one-to-one laptop' classroom. For him the experience with the laptops supported his beliefs about when and how technology should be used. Rick used a very teacher-directed pedagogical approach, and he used technology to support this didactic style.

The experiences of these teachers show that despite varying beliefs about the role of technology in teaching and learning, and a variance in expertise using technology, all three of the principal participants felt that teaching with the laptops was a positive experience for them and the students. Interestingly, both Carly and Laura directly stated that they would not want to go back to an environment where they were teaching without laptops, while Rick, the teacher with by far the most experience with technology, was indifferent. He reported that without the laptops he would just "...use the lab more".

Access to reliable laptops lead to increased integration of several types of technology

I have couched this section with the preface *reliable* laptops, because without access to reliable, internet-connected computers in the classroom, none of the other factors which influence how much a teacher will integrate technology has any effect (Norris, Sullivan, Poirot, & Soloway, 2003). The principal participants in this study had varying comfort levels with technology in September of 2006, but by the end of the year all described themselves as being very comfortable with integrating the mobile lab of laptops into their classes. This is not to say that they felt they had all of the answers, and in fact it was quite the contrary. While they used terms such as "natural" and "comfortable" to describe the laptop use in their classes, they also articulated that they felt they were just beginning to learn how to use them effectively in order to get the most benefit from them. These teachers had reasonable expectations for how much they could do and how soon, characterized by Carly when she talked about "...kicking it

up a notch next year". Parson's (2006) examination of Alberta Initiative for School Improvement (AISI) projects involving technology supports this, intimating that learning to integrate technology into a constructivist environment will not happen in one year – it takes several years to build the pedagogical expertise, the technical ability, and the comfort level in teachers. In the ACOT study mentioned in the previous chapter, the teachers had similar experiences in their first year. Like teachers in that study, the struggles with using the hardware abated after the first few months, and the issue then became *using* the technology as an effective tool in teaching. Called the 'adoption' stage, it was characterized by the use of technology to support existing practices (Sandholtz et al., 1997).

For Carly, the familiarity gained in having the students frequently working with laptops, empowered her to try to introduce other technologies into her traditional style of teaching. She began using online video, digital photos and DVD film clips to illustrate concepts – something she had always done with text, overhead transparencies, or verbally in the past.

> I'm more comfortable with the computers, so now instead of putting an overhead on, or telling a story about something, like the Alkali metals, I'll put up a video I found on YouTube... Instead of me saying that "this alkali metal, when it mixes with water it's going to go "boom"...they see it, it's different.

In September, Laura was apprehensive, but excited, about using the laptops with her students. In informal conversations, she reported that her inexperience with technology, and the fact that many of her past experiences with outdated technology had been ineffective, left her wondering whether being part of the mobile lab project would be a worthwhile endeavor. As the year progressed, she became very comfortable with having the laptops in her classroom, to the point where she was being playfully teased by other staff members for signing out the mobile lab cart at every possible opportunity.

While some previous studies suggested that the teachers' technology skills positively impact technology integration (Silvernail, 2005), findings in this study more closely align with Vannatta and Forhham (Vannatta & Fordham, 2004) who suggest that rather than technological expertise, a combination of technology training, time spent on planning outside of contractual time, and an openness to change are the best predictors of increased effective technology use. The openness to change was certainly evident with the participants in this study. Both Laura and Carly made significant changes in how much they used technology with their students as the year progressed, moving from the obligatory trips to the lab, to integrating the laptops and other technologies into their daily routines. By June 2007, these teachers showed they were in what ACOT describes as the 'adaptation' stage (where increased productivity is the hallmark), with some examples of being in the 'appropriation' stage (using technology effortlessly to accomplish real work)(Sandholtz et al., 1997). For example, in Rick's class, he

encouraged students to demonstrate their understanding by asking them to build on existing projects and elaborate with words and pictures. This fits with 'adaptation' because he was taking a project he had always done without technology, and enhanced it by letting students use the technology throughout each phase of the project.

Shift towards a more student-centered approach

Teachers willing to give up control

> Most teachers ground their entire careers on establishing a monopoly of control in the classroom...teaching what they want, when they want, anyway they want to teach it. Bringing a wireless laptop into this environment, which means forfeiting some of this control to students, is a much tougher sell than a new textbook or lesson plan. (Milner, 2005, p.28)

Teachers reported that they spent more time planning and preparing, and less time teaching in front of the class and grading student work as the year progressed. Carly, for example, felt that her teaching style had changed "quite considerably" over the ten months in the project, estimating she doubled the amount of time she spent in a facilitator role. She felt that by allowing the students more flexibility in choosing the level of reading or topic, she was able to more easily manage class behaviour, and spend more time helping those individuals who needed it. In the classes I observed, she was providing an introduction to the students, and then directing them to develop answers to the 'question of the day'. In addition, she provided more open-ended projects and attempted to differentiate instruction more than previous years because of access to rich resources on the internet and increased student engagement, but this process did not happen overnight.

In early observations (November 2006) in Rick's classroom, it was apparent that he relied heavily on a highly structured didactic style, and strictly defined behaviour expectations in his daily routine. Students were nearly silent throughout the lesson, with Rick at the front giving instructions and calling on individual students to answer verbal questions one by one. In one lesson, Rick presented a concept in math, then distributed a worksheet and had students access a website using their laptops to assist them in completion, fitting with the *adoption* stage of the ACOT continuum by using technology to support his traditional instruction. Students were very quiet, attentive, and certainly were aware of all behaviour expectations. All were in their seats, in their rows, facing straight ahead. During my second observation in January it was a very similar scene, with students completing tasks as Rick gave instructions from the front of the room. There was a difference in Rick's journal entries at this point, as he began to allow students some flexibility in how and where they would complete their work. For example, in a February journal entry, Rick states:

> As a motivational technique, I have allowed students who have consistently demonstrated responsibility in completing work on time and focusing on the task at hand the opportunity to work outside of the class. Most of these students have really stepped up and seem to enjoy the extra trust that they have been given to do their work outside of direct supervision in the class. Some have shown that they are not yet ready for such a responsibility, and after losing the privilege are keen to ask how they can earn it back.

In contrast, a class observed in May had the students collaborating in completing an open-ended science assignment, sitting on the floor with others (or under a table), using a variety of software programs (I observed them using *PowerPoint*®, *Word*®, *Stellarium*®, *Google Earth*®, various search engines, teacher-approved web-sites, and *ReadPlease*® during this one class session). The classroom remained very quiet, with each student completing their own assignment. The difference from the previous observations was that they were encouraged to work with others in researching their topic. Rick made his way around the class, probing with leading questions, while students busily worked or asked each other questions. Rick's entry from the online journal demonstrates a shift in his teaching style and is consistent with the comments from all participants:

> As a teacher, I found that I was able to change the methods of instruction that I could use because of having the laptops. As the students became more proficient with the laptops, I was able to challenge students capable of learning more independently with more open-ended assignments, encouraging them to demonstrate their understanding of a concept, while allowing me to spend more time with those students who needed more support.

Laura, the teacher who came to the project with the most experience and comfort with project based-learning, and who was further along on the continuum between teacher-centered to student-centered, was less adamant about how much the laptops changed her teaching practice. She considered the inclusion of the laptops in her classroom as simply giving her more tools to do more of what she had always been doing. However, she did remark: "I don't think I could go back to lab life. Having the lap tops in the classroom just seems so natural for me and the students."

In Carly's case, while she talked about her teaching style being quite different from the previous year, her teaching style did not change much *during* this year. Rather, she found more innovative ways to integrate the laptops with her own style.

> I love the flexibility of the mobile lab. The students can move, sit together, way better than the lab...and I would love a SmartBoard® [interactive white board], but if I had to choose I'd get more laptops

> because the SmartBoard®'s just means more chalk and talk, and that's not my style.

She had more issues with access to the laptop cart than the other teachers, since she shared the cart with five other science teachers in her department and was often limited to one class of access per week with some of her classes. (Recall that Rick's students had full-time access to their own laptops, while at Laura's small school, there were only two other teachers who used the mobile lab to any degree.) For this reason, she would plan activities that would require students to access information on the internet and not go too much further than that. She agreed that most of the time her students used the laptops for internet research and accessing online digital learning objects, and not for higher-order thinking skills such as creating, collaborating, or synthesizing. However, having even this limited access did allow her to try different approaches with her students:

> So my daily routine, my standard teaching style has changed quite considerably, where I'm not in front of the kids as much, and I'm not controlling their learning as much, which is...well...I am, to an extent, am controlling it more, but it's more of just a push in this or that direction rather than giving them exactly what I want them to use.

Technology access can have a profound effect on a teacher's pedagogy (Sessions, 2006). These teachers experienced a change in their teaching style as a result of experiences in planning and using technology with their students. Each of the teachers came to the project with their own pedagogical style, and with very different experiences using technology in the classroom. While each started in a different place, all experienced a shift along a continuum spanning from a teacher-centered role, to that of a facilitator in a more student-centered classroom. For example, Laura used technology to augment an already student-centered approach and gave more control to her students, and Carly moved to a point where she felt she was acting as a facilitator much more frequently and was willing to give her students more responsibility for their own learning.

Did access to wireless laptops move the teachers towards more of a constructivist approach, as some studies (Davies, 2004) suggested? Or did the style they had developed and demonstrated over their teaching careers thus far, influence how technology would be integrated? There was evidence of both in the data. During the focus group interview, Rick discussed students collaborating and having the flexibility to move around the classroom to work on group projects, yet in classroom observations, students were working on their own on individual assignments. Some would be sitting with others on the floor or under a table, but they were most often working independently. There may have been a slight shift *towards* a more student-centered approach, but there was never any question that Rick was very prescriptive and directed the learning of all of the students in his class. This fits with the research findings of

Judson (2006) who found that while many teachers identified strongly with constructivist ideas, they did not exhibit many of these ideas in their teaching.

It should be noted that when I mention 'shift in teaching style'as a result of having the laptops in the classroom, I am not implying that there was something deficient about the teachers' inherent style. This is not my intent, nor did the teachers in this study indicate that this shift was more than was necessary to take advantage of the opportunities the increased access provided them and their students. Laura, for example, made it quite clear that she continued to teach the way she had been teaching, and assessing as before, but it was the student engagement, willingness to revise, and range of presentation options that made it necessary for her to change how she approached her classes and planning.

Participants initially felt apprehensive about relinquishing control over what happens in the classroom, something that seemed to 'naturally' happen when laptops were introduced. One factor that eventually made it easier for the teachers was the first-hand evidence of engagement and motivation that happened from day one. What they found, and what is clear from the evidence in the data, was that changing their teaching style – in part by giving up some control by allowing students to work *differently* using technology – resulted in many positive outcomes.

> It's hard to give up that control. It's a real paradigm shift for us to think that way...even though we know that they are going to be engaged and motivated and will be successful if you change how you teach to let them have that freedom, but there's that part of you that still wants that control. - Carly

These included more on-task behaviour, student self-direction (students taking the initiative to look into questions that piqued their interest), students helping other students, and an increased willingness to use formative assessments from the teacher or peer feedback in order to edit and improve their work. An example of self-direction came from a report in the online journal where Carly reported that students would self-select resources to use for assignments, depending upon their level of expertise and comfort level with the technology. In one lesson, students were creating a concept-map (using *Inspiration*® software) to review a unit in science and those students who were unfamiliar with the software, sat together in a group while the teacher and a couple of the students shared instructions on its use. Those who were familiar with the software, but who were unsure of the content, organized themselves into other groups to review content. Those who were familiar with both the software and the content, and who completed the required concept-map early in the class, spent the remainder of the class accessing online learning objects and videos that related to the content, in preparation for the unit exam. The teacher was able to move between the groups, providing guidance where required.

> That's a big motivator for my kids - the kids saying, "Don't worry about that Mrs. D, I'll show you how that works. So sometimes you just "play ignorant" and then sometimes you have to beg them when you really don't have a clue! Because you've got to save face sometimes! - Carly

As these teachers became more comfortable with technology, differentiation was observed in all three of the areas at both a formal and informal level. Teachers made leveled materials available and students were able to choose and fluidly move between levels as required. In previous years, Carly would try to provide leveled resources for her students as much as possible, but finding articles and resources, then copying, organizing, and keeping them current, was very time-consuming. In addition, students who should have been using the more basic resources often would balk at this, feeling as though they were being singled-out since others could see that they were choosing the easier resource, for example, as opposed to the more advanced resource. In the science classroom at Forest Park for example, the teacher would have the day's resources on a document on the file server, and students would simply access that document each day. It included links to resources at three different levels. Since the resources were all online, students could quickly examine the linked sites or documents and choose materials at a different level if necessary. Often the resources she found for the struggling students were much more media-rich and interactive, so students at all levels would access them. This resulted in a classroom where she says "...it makes it invisible that they are working at different levels." Other comments included perceptions that the laptops "leveled the playing-field" for all students by giving some students who needed assistance (in spelling, grammar, handwriting, or with added auditory or visual support) what they needed to complete their assignments. An example of a 'leveled resource' is included in Appendix C, in which Carly asked students to access at the start of an observed class. She would ask students to choose from one of three websites listed – she would label one of the links 'challenging' and another 'general' - each at a different comprehension level.

On occasion, students were the ones finding the resources that fit best with their learning style or comprehension level and then shared these with the teacher and other students. Carly described an example where a student found a great article which demonstrated a concept from the 'space' unit. In the past, she would have made copies for every student, or summarized the article for the class. In the latter case, those students who were not strong auditory learners may have suffered, or may simply have tuned-out the teacher. With the laptops in the classroom, the same resource could be identified and spread around the room "...like wildfire..." in moments, without the teacher initiating it. Teachers also indicated that there was a lack of current print resources at their schools, certainly not enough to support all of the students who needed reference materials for a particular unit project. Carly stated, "...we'd use books from the library and then one person gets the 'good book' and wouldn't share it." Access to a wide variety of resources online alleviated this problem.

The evidence above concurs with Davies' study of the Maine Laptop Initiative (2004), which found that when each student in a classroom had their own laptop , "...students can pace their own learning, going faster or slower as needed, without other students being aware" (p. 39). In addition, technology provides opportunities for teachers to meet the needs of students with various learning styles through the use of multiple media (Harris, 2004). For the teacher who is beginning to differentiate learning in the classroom, differentiation may begin by making variations in *content*, *processes* or *product* for each group in the class (Diamond & Theroux, 2002). In the examples above, Carly was varying each of these elements to some degree.

Whether you refer to these students as the "net generation" (Tapscott, 2006), "digital natives" (Prensky, 2001), or "tech-savvy students" (Education evolving, 2005), they have several things in common. They have never known school without the internet, word processing, presentation software, and a variety of digital resources and tools. The oldest students taught by teachers in this research, entered grade one in 1998, a full two years after Alberta Education made it explicit that technology should be part of every child's education by releasing the *Implementation Plan for Technology in Education* (Alberta Education, 1998). The youngest students have not known school without Alberta's *SuperNet* (Alberta Education, 2007). These students use technology on a daily basis to communicate, research and create – though not necessarily at school (Media Awareness Network, 2005). It is not surprising that when these students are provided the tools they are comfortable with, in this case internet-ready laptop computers, they are excited about taking more control of, and more interest in, their own learning.

Fitting with the move towards increased differentiation, all three teachers reported they provided students with more options for representing their knowledge in project work because of the access to technology. For example, in the past Rick would provide students with concrete parameters for completing a solar system assignment, including the format, the number of pages required, and the elements that needed to be included. Now, he provided a general outline of the content and understanding he expected, and then allowed the students to choose how they would complete the assigned work. He said:

> For projects, I give them the basic outline of "this is what I want to see, this is the concept that you have to be able to show to me", and then however they kind of color inside of the lines is what they do... they go so much beyond what you would normally expect if you just said "this is the assignment".

While the types of projects assigned by the teachers initially did not change once laptops were introduced into the classrooms, the types of products the students were creating to "...color inside the lines..." changed significantly, fitting with the 'adaptation' stage described in the ACOT study (Sandholtz et al., 1997). Teachers would typically assign projects which were similar to projects assigned without technology, but would

now also provided a rubric that gave students flexibility in how they demonstrated their understanding. It does not come as a surprise to me that the vast majority of students chose to complete project work using the laptops when given the choice. By this time in their academic careers, they had limited opportunities to use technology and it was novel for them. Other studies which have been conducted over several years have shown that student engagement does not significantly decrease from year to year (Davies, 2004; Hillis, 2004; Swan, Hooft, Kratcoski, & Unger, 2005), suggesting that it is more than simple novelty that drives students to be interested in using technology.

Teachers believed that students developed an increased awareness of, and responsibility for, their own progress as the year progressed because they did not have to wait for feedback from the teacher or peers – they could get it from the software they were using. For example, Rick talked about how in past years he spent more time in class quickly proofreading writing assignments for students at their desks while they worked, or answering questions about spelling and grammar. With the laptops available daily for writing, students learned to use *ReadPlease®* (text-to-speech software) and the spelling and grammar tools in *Microsoft Office®* to review their work for themselves first where they often caught many of their simple errors. Students in his class, who struggled with reading, would cut and paste text from web pages into *ReadPlease®*, which was installed on each of the school's laptops. Students, using their headphones, would listen to the content as they read along, as well as access the built-in dictionary and thesaurus features to help them with any terms they did not understand. While his students did use peer-review as a strategy at times, they would also use the text-to-speech software to proofread their own work. Now that the students were more self-sufficient and could do more proofreading themselves using software, he was able to spend more time helping students with content instead of spelling and punctuation.

For Carly, the immediate feedback came from the online quiz software she and her colleagues used (*Quia.com*, discussed earlier), which allowed students to check how well they knew their facts using pre-tests before taking their online multiple-choice tests.

> I have been trying to get my students to be self reflective and self-assess for a long time. It is so much easier to do with the computers as it just makes more sense to them this way. Maybe because they can get immediate feedback and can see how the learning objectives flow for them as individuals. This is very satisfying to see as a teacher.

There was a cumulative impact on the teaching and learning that resulted from having increased access to technology in the space where their learning normally takes place (as opposed to a computer lab). Laura, for example, perceived that the depth of learning that was taking place was changing in relation to her students' cross-curricular project on the topic of 'forests and trees'. Students were creating presentations about their assigned topic and were also asked to review it from a grammatical and writing-conventions perspective. She found that some students asked to continue to revise their work long after it was considered 'complete'.

Similarly, Carly felt that although students took a lot longer to finish projects with the laptops, when compared with her traditional methods of instruction, they had a better understanding of the material.

> With *chalk and talk* [without the laptops] I can get through the lesson, give them the quiz the next day, and move on to the next idea. So they can regurgitate the answer, but do they know it as well? ...they seem to really be comfortable with the concepts and when we've given them their unit exams, our kids this year, when we compared them to last year, are higher across the board - we have higher averages, so I think the kids are *getting it* better.

This statement also exposes another benefit of bringing a disruptive technology, such as laptops, into the classroom. It has made the teachers reflect on their teaching at a level above the day-to-day operations of the classroom. As evident in the quote above, Carly was quite familiar with the "chalk and talk" style, but through the year began to question this approach, reflecting on her teaching style and making a conscious change based on what she was observing in her classroom.

Students were more willing to collaborate with other students and their teachers. In the laptop classroom, students would take the initiative to ask other students (or their teacher) for feedback and had few qualms about revising as many times as necessary, since this was much easier on the laptops when compared with the arduous process of repeatedly re-writing by hand. As Laura commented, "They could change it, and it was automatically changed and done and they were very excited...they don't have to go back and rewrite ten pages, because they wouldn't." This resulted in better, more complete work students were proud of, but which took more time.

Carly commented on how the on-demand access to a wealth of resources that the wireless, internet-able laptops provided allowed her to make science more relevant to her students. Students were now finding resources at home while online, and sharing them with her via email. They would delve more deeply into subjects that interested them and were able to quickly share the 'cool' resources they found with others in the class.

> For my kids...their understanding of science and it impacting their everyday has changed. Instead of having to do the wall and the articles from the newspaper, we do the "Science in the News" and they'll say, "Guess what happened!" They're finding these things themselves. ...I mean it made the whole debate in science relevant for the kids because they could access the information right now, that's brand new.

There were indications that teachers believed student understanding was *deeper* when technology was integrated into lessons using laptops, based on their informal

comparisons between present and past student work, and the degree to which students were willing to extend their own learning. The examples provided above by the teachers, show that these effects were neither universal nor planned. There were individual examples of students who would latch on to a concept presented in class and follow-up on it by researching further at home. Often these students would share their extended investigation with students the next day.

Students' willingness to help each other changed as well. This took some pressure off the teachers, who initially felt they would be spending a lot of time troubleshooting technical issues. There was a certain prestige in being able to troubleshoot technical issues for someone else, or show how to use an advanced feature of a software application, and this spilled over into helping each other with non-technical issues as well. This collaboration is also related to the ease of editing their work. Laura reported that "collaboration...is very natural for them...", and described above how students were eager to share what they were doing and get feedback from others to improve their work since revising was not a chore.

Teachers also made the comparison between their perceptions of how students worked in a computer-lab environment, versus how they worked when the laptops were in the classroom. In the lab, most students faced their computer and the wall of the room, and very little collaboration took place. In the classroom, not only was it a comfortable space of their own, but students could move their desks, sit on the floor beside each other, move to a large work table at the back of the room, or even work in another area of the school if they wanted to. With laptops instead of desktop computers, there was more fluidity and they could work together more easily.

> There was never any hesitancy on the part of the students to share ideas or to share resources. In the past, it was only when they were writing and we would have scheduled times when they'd be doing peer editing... Now it's any subject, no matter what the activity is - they are using the laptops and they want to work with a partner, and be able to share and talk about the information that they are finding. - Rick

This flexibility promoted collaboration between students, as they were not tethered to any particular place and created more of a fluid work environment. Jukes and McCain (2000) talk about schools designed for the industrial age, where public school students are being prepared for a society where careers are linear, much of the work is based on hourly work for a wage, and where a superior gives directions to be followed and the subordinates follow the directions. Contrast this with a new generation who should not be expected to memorize information, but to create meaning. These students have access to an ever-increasing amount of content; recalling the content is not an issue as any grade four students with access to *Google*® can attest. Sorting, validating, and making sense of this content *is* the issue for these students, and should be of paramount importance to teachers. Students who can collaborate, create, and communicate what they know will be the knowledge workers of the next century (Florida, 2004). The

flexible environment that laptops helped create enabled a shift towards this type of learning.

Changing classroom environment

Assessment was easier

> "If we got rid of the laptops next year, I would really miss knowing where my kids are at so easily, and I don't know if I would have the same depth of knowledge of whether my kids understand the curriculum without doing a whole lot of extra paperwork that I really don't have time for." - Carly

Teachers expressed they felt more aware of student progress in general, and had a deeper understanding of the degree to which their students understood the curriculum. Since more and more of the student work was being completed using the laptops and then saved to the school server, the teachers had much easier access to student work and could check progress and assess at any time. In addition, a combination of students being more self-directed and a corresponding shift in teaching style towards a facilitator role, resulted in the teachers having more time to work with selected students. Laura's comments summarize the feelings of all three participants accurately:

> It makes it easier for me to keep track of what they are doing. I can go into their network folder at any time and see what they've been working on...In the past it was a paper chase - they're not going to always leave that paper behind in a place where I could easily find it. - Laura

She described similar situations and also remarked that she felt much more connected with the progress of each student because of several factors. One was the increase in one-on-one time she could have with each student as a result of a pedagogical shift to a facilitation style. During one class observation, the group was writing using the laptops at their desks, while she met individually with students at a table in the back of the room. They would bring their work to her on their laptop and she would provide formative feedback. Another example was the ability to have immediate access to student work on the network. In-class access to the software they wanted to use to complete assignments meant that less student work was being completed at home where she could not keep track of what students were doing.

This is consistent with results reported in a wide-scale implementation of laptops in the state of Maine (Davies, 2004). Teachers also used different types of assessments and were able to shift from summative to more formative means of assessing because of the flexibility offered by the increased access to technology. For example, at River Glen, teachers were using the 'track changes' feature in 'Microsoft Word', which creates

annotations in the form of high-lighted balloons inside of the documents, to provide specific, constructive feedback to students. Teachers were also able to easily collect exemplars of student work to use for assessment. Laura remarked, "...It narrows down that whole paper chase. Instead of 'I have to photocopy this file for this, and keep this file for that'...now I just have it." She saved exemplars of excellent, average, and poorly done projects so that students could compare their work with these benchmarks and self-assess accordingly at any point during their assignment. In *Assessment for Learning,* Stiggins (2002) notes that part of providing effective teacher feedback includes describing why an answer is right or wrong in specific terms that students understand. He also notes that students can generate their own descriptive feedback by comparing their work with teacher-provided exemplars or posted samples. They can then compare their own feedback with that of their teacher. This was enabled by the teacher and students all having access to posted exemplars on the school network, and the laptops allowed the students to keep working on their assignments, while the teacher could look at it at any time and provide feedback.

In addition to this new method of assessment, some teachers used the technology to support their traditional modes of assessment (the 'adoption' stage of ACOT) using online assessments such as simple summative science quizzes. Carly found it much more efficient to grade online quizzes. Science teachers at Forest Park purchased a subscription to *Quia.com*, which allowed them to create and share online quizzes for their shared classes and eliminated the need to manually grade certain quizzes.

Teachers relied more on collaboration in their planning.

Teaching to a classroom full of students who each have a wireless laptop with high-speed internet access was initially frightening and brought with it many challenges for the participants. One of the major challenges was planning for learning activities that were often unlike any these teachers had planned in their careers to date. Teachers had many different professional development opportunities available to them to address these challenges, including two full-day summer professional development sessions, an online community where they could share ideas and resources, and individual support from consulting and technical staff. Despite this fact, most of the professional development that occurred at the schools was quite informal, took place between colleagues teaching similar subjects, and often had very little to do with the actual technology. The teachers hesitated to relate it to technology because for them it was collaborative curriculum planning, where the technology was secondary.

> ... [W]e have those informal hallway discussions, where someone says "try this" or "have you tried that", or we email some assignment ideas back and forth to try and figure things out... Nothing formal. - Laura

Teachers were planning for teaching with the laptops in a fashion similar to how they would plan for teaching without the laptops. They reported that discussions were generally about the curriculum and how technology could support it, and not about

teaching how to use the hardware or software. In this way the teachers were beginning to learn much like the students were learning and were starting to use the laptops as the students were – just as a means to an end, which in this case was teaching science, language arts, or their other subjects.

A number of researchers had similar findings and reported that they observed teachers helping each other with technology problems, or engaging in joint curriculum planning, and some have even reported that teachers prefer this form of professional development above others (Silvernail, 2005; Windschitl & Sahl, 2002). As evident in these previous studies involving mobile labs of laptops, teachers relied on one another for expertise and only on occasion brought in external consultants for professional development sessions. None of the teachers who participated in the study were involved in any workshops or classes involving the use of a particular software or hardware. Instead, they relied on answers from their colleagues to technical and pedagogical questions posed over lunch hour, in the hallway during a break, or after school. Stevenson (2004) also found that teachers felt that informal collaboration was more effective (under certain conditions) than formal workshops or sessions on technology.

Work load was not heavier, just different.

During the focus group interview, teachers were asked about their perceived work load and their motivation at work. Participants agreed that teaching with a mobile lab of laptops was not more work, just *different* work. Teachers reported that the amount of student writing increased as a result of introducing laptops (to be discussed later in this chapter. From one perspective, having the amount of student writing increase ten-fold is an extremely positive outcome. Students who write more, and who become comfortable with a writing-feedback-editing loop can become better writers and increase their writing achievement (Davies, 2004; Gulek & Demirtas, 2005). However, for the teacher, this also translates into a potential ten-fold increase in the amount of writing that could require formative feedback. Teachers in this study addressed this by encouraging students to solicit peer feedback, but also found it much easier to read and provide suggestions to students because they could access their work online. In addition, Laura reported that in previous years many of the students would take their rough copies home and work on them on their home computers, and she would not see their progress until it was too late.

> [With]...laptops, the whole process is done in front of me and with me, instead of bits and pieces and then it goes away and you don't see it until the finished product. Kids still take their work home on memory sticks, but it still comes back and forth in chunks that we can look at together. I feel more connected with what they are doing.

While time was saved due to these factors, teachers felt that *more* time was required of them in planning how to best use the technology with their students. They claimed it

was a worthwhile investment, as they were learning about what worked well and what did not, and could apply this learning to how they integrated technology into the classes in subsequent years.

Continuing to develop best practices for creating, storing, and viewing materials online in a well-organized fashion, will progressively lighten the teacher's work load, giving them more time for planning learning activities which integrate technology in meaningful ways for students. While some studies have had participants who reported that integrating ICT has increased their work load (Moyle, 2006), the teachers in this study were clear in their feelings that it was neither more nor less work, just *different* and in addition, found this work professionally stimulating.

Classroom management became easier with more on-task behaviour.

How teachers managed the students in their classrooms changed. Behaviour issues were rare, and routines in managing the technology became very important. By March 2007, teachers were beginning to report that they were able to focus more on teaching and learning instead of on how to use the technology. By this point in time not only had most of the issues with logging in and connectivity to the wireless local area network (WLAN) been resolved, but the students were also very familiar with procedures for getting the laptops from the cart, getting logged in and finding the files they needed for the day's class. Earlier in the year, some students would wait up to fifteen minutes to get logged in. The teachers developed strategies such as saving their independent reading time for these times, or teaching the students how to troubleshoot their own issues. If there were any technical issues, SWAT team students at River Glen would help others get logged in at the start of class, thus freeing up the teacher to carry on with her normal lesson preparations.

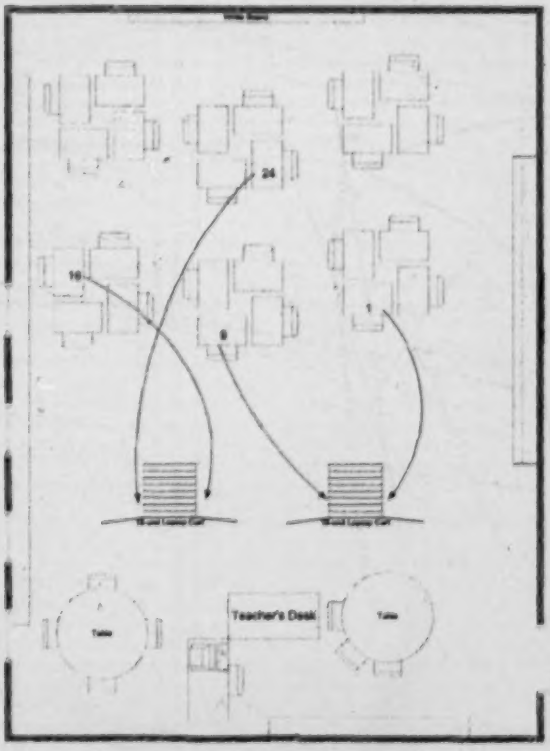

Figure 4: Laptop distribution at River Glen

As the year progressed, all schools developed more efficient protocols for managing the equipment in a laptop classroom.

Specifically, at River Glen elementary the SWAT team was responsible for bringing the laptops to the room when called on by the teacher. They would place the carts at the back of the room and open the doors so that students could access the shelves easily. Instead of students lining up all at once to collect their laptops, the students would walk up in sequence, with the person assigned to the first shelf on each cart coming up first, as shown in Figure 4. When they had left the cart area, the person whose laptop was on the second shelf would come up, and so on (there were sixteen laptops in each cart, eight on each side. The students would log on to their laptops as soon as they sat down at their desks, thus staggering the log-on process and reducing network traffic. This procedure allowed the entire class at River Glen to get their laptops, and get logged-in in under four minutes.

Increased student engagement and pride

The quantity and quality of student writing improved.

Several studies have suggested that student writing improves with access to laptops (Davies, 2004; Harris, 2004; Jeroski, 2005). For these participants, this was primarily due to the students' willingness to revise their work based on feedback. With the laptops, students were actively seeking feedback, instead of avoiding it. Over the course of the year, students became critical of their own work and used this feedback from teachers and other students to make their writing better. There was anecdotal feedback that the weaker writers benefited the most from the increased access to technology. Being able to read their own writing, and an increased pride in their work, contributed to their wanting to write more. The reasons provided for an increase in writing quantity and quality, had little to do with the fact that these were laptop computers, but simply that students had increased access to a word processor. Other studies using PC's or portable word-processors, and not laptops (Plotnick, 2004) had similar positive outcomes. Being able to find written work quickly, easily make edits, and end up with work that was presentable, all added to students' willingness to write. For this reason, they wrote more, and in writing more, became better writers.

Students were engaged by the technology; enjoyed using the laptops.

Laura identified the change in overall student engagement among her grade six students as the biggest single change in her classroom after the introduction of laptops. Work that was assigned using the laptops was "one-hundred percent completed", whereas in the past there were always issues with students losing rough drafts or notes, or simply making excuses for not completing work. The teachers felt that the students were genuinely excited about using the laptops for their school work and voiced pride in much of the work completed. Teachers felt that having the option to complete projects and assignments using the laptops continued to be a motivating factor for students on a consistent basis through the year – something that had not been observed with the traditional computer labs.

> ...they're in a rush to open them up so they can get to work, I also find as well that motivation is built in for what they're doing. I don't have to cajole them or say "this is going to be really interesting for you to do - I just tell them "this is the assignment, this is what you can use the computer for" and they just want to go...let's get to it...the faster I can get the instructions out, the more time they have to work. - Rick

While the novelty of simply having *access* to laptops in the classroom did eventually wear-off, the students' motivation did not. Early in the school year, teachers expressed frustrations with students who were testing the limits of the equipment, seeing how far they could go in terms of being able to customize the desktop theme, screensaver, and programs, but this soon became a non-issue for both teachers and students.

> I thought that motivation factor would drop off after they'd used them so much all year long, but they still...I mean this is an affluent neighborhood, these kids have technology at home - they have more technology at home than I know how to use...but the motivation is still there because it's in-school, it's in the classroom." – Carly

This is not to say that every activity done with the laptops met with unequivocal success in the eyes of the students. In the grade nine chemistry unit, Carly decided to replace a traditional lab activity with a simulation using the laptops. Her rationale was that in another unit, dealing with electrical circuits, the students loved the online simulation, as it allowed them to test various configurations without having to worry about poor connections, burned-out light bulbs, or dead batteries. However, referring to the chemistry unit, she says:

> The kids hated it, they didn't do as well, they rushed through it, they had no interest in it...the assessment I gave them afterwards they bombed. They didn't have the hands on and they didn't do as well.

When she compared the two simulations, she felt the students were less engaged in the chemistry simulation because they anticipated an actual lab where they could see, feel, and smell the reactions.

There is significant evidence that students in today's classrooms have a desire to use technology in rich and diverse ways, and they often feel stuck in a system that is text-dominated. Students identify that frustrations for them include limited access at school to fast, reliable, networked computers, and also a lack of activities which required them to use technology in a challenging and technologically-oriented ways (Education evolving, 2005). The teachers in this study reported that a primary factor in their willingness to incorporate technology into as many areas of their teaching as possible, was the increased engagement level of the students when they were using the laptops for school work.

At the start of the year, the students were motivated to use the laptops for nearly any type of activity, but as the year went on, access alone was not enough. The opportunity to both observe at regular intervals and read teacher journal entries throughout the year, revealed an interesting back-and-forth dance that was happening between the teachers' comfort level with technology and the students on-task behaviour. Early in the school year, teachers revealed their apprehension about giving a class full of students an expensive and delicate piece of technology. Their apprehension was based on both being unsure of how to plan for learning experiences with the laptops, as well as with anticipated classroom management issues (e.g. students aimlessly browsing the internet, playing games or being off-task). From journal entries in the fall of 2006, it was apparent that student engagement in using the laptops was making a difference in classroom management for all teachers. All three participants agreed that the motivating influence of being able to work on the laptops, increased students' on-task behaviour, and thus they spent less time dealing with discipline issues. They reported that students were interested and actively involved in classes when the laptops were present, that all students completed their assignments, and that they were excited about using the laptops when compared to completing similar work without technology, or with technology in the computer lab.

Without behaviour issues to contend with, the teachers became more confident in using the technology, and over time thought of more innovative uses. The students responded to this with the same kind of engaged enthusiasm, thus supporting the teachers and making it even more comfortable for them to take risks in using technology in other ways. As described by Davies (2004) in a study of children using laptop computers in the state of Maine, "The teacher refrains from using strategies that no longer work, increases the use of strategies that do work, and incorporates new strategies that work in the changed environment " (p.39).

In their lives outside of school, children use technology for communication, information gathering, learning, and entertainment (Education evolving, 2005; Lamb & Johnson, 2006). By providing reliable access to wireless laptops in the classrooms and allowing students to be flexible in how they use them to meet the learning goals determined by their teachers, schools can become much more relevant to students. It is this relevance to the reality of their daily lives that engages students and allows them to function in a way that is natural for them.

Students were proud of their work and wanted to show it off.

Teachers felt that both the quality *and* presentation of student work improved, and because of this, the students expressed pride in their completed work. Capable writers who had poor penmanship, no longer minded having their work posted on the bulletin board outside the classroom. Their work was now as neat as any other student's work. Students were able to easily refine and edit their writing and presentations again and again. When they were exactly as they wanted them (after feedback from peers and the teacher), the finished product was much more polished. Teachers at the two

elementary schools felt that when they used the laptops to complete work, students had more pride in the work. The 'Trees and Forests' presentation described above demonstrates how students took pride in their work. When the students felt they were complete, she met with each one individually and provided feedback on their work from a Language Arts perspective. Students were then able to go back to their presentation and refine it even further. The students, whose work was already exceeding expectations, were able to look for additional information using online resources to further enhance their work. Students whose work was not meeting expectations were able to go back and edit their work as well. When asked during the focus group interview about how her students had progressed through the year, Laura says,

> Have they become more independent and self-directed? Yes... but I couldn't say that it's the implementation of the laptops themselves that have made *all* of the difference. The whole framework, whether you call it assessment or differentiation, this is the tool that helps them to see where they're at and where they need to go. Would they still be able to see [that]... without the laptops? Yes, because my group last year could, but in the end, these guys that I have right now...have more of a sense of accomplishment and pride.

Students also demonstrated pride in how they took responsibility for the equipment. In online journal entries, participants commented frequently on how carefully the students handled the laptops. Observations in the classroom supported this, as students were gentle when opening and using the hardware, and were very methodical and cautious when carrying the laptops to and from the mobile storage cart. Teachers attributed the behavior to two things. The first was the attention given to procedures developed at their schools for the distribution and collection of the equipment, which were practiced and reinforced repeatedly. For the second, they gave a lot of credit to the students: "The students have pride in being the ones who get to use the laptops so they take care of them."

I have reported how teachers felt that access to technology helped those students with poor writing skills the most. Students reported to teachers that they felt more comfortable displaying their work on hallway bulletin boards when their writing looked the same as every other student's writing. Several teachers indicated they consciously tried to be impartial, but felt they may have been inadvertently bias toward the work completed with neat handwriting. Having more of the student work done on a word-processor allowed them to focus more on the content, and less on the presentation of the written work. With students demonstrating more pride in their work, they were encouraged to write more, and this increase in writing may contribute to their writing ability over time (Davies, 2004).

Other findings

Students had a wide range of abilities with technology.

The elementary students did not have much experience with using computers for learning, since their experience in the past had been one-shot, "write-and-print" experiences in the lab. The junior high students were considerably more skilled in the use of the laptops, having been part of a group that had all taken a mandatory computing course in grade seven. Carly still felt that most had trouble with tasks such as determining the validity of a website.

Keyboarding specifically was a barrier to writing for many. The two elementary schools had keyboarding software installed on the laptops and students could keep track of their own progress, but Rick spent much more time early in the year working on keyboarding skills. The group at Lane Way, who had access to their laptops all-day, every-day, during the school year, became very capable typists and all felt comfortable writing their Provincial Achievement exams on their laptops. In Laura's grade six class at River Glen, only eight out of twenty-seven chose to write their exam using the laptop, perhaps due to their perceived (or actual) lack of proficiency at keyboarding. Participants felt that keyboarding skills were important, and they recommended more time be spent on developing this skill in the future. Carly, the junior high science teacher, did not report any specific issues with keyboarding. In classroom observations, her students were using the laptops more for reference and looking up information. Much less time was spent composing, and she reported that her older students had functional keyboarding skills.

It was evident that there was a learning curve for both teachers and students. While the students were certainly comfortable using the laptops, were willing to experiment and try a number of different approaches when something did not work, they were not as technically savvy in some ways the teachers expected. Students had difficulty with managing information, namely saving files properly, organizing their files, conducting effective web searches, as well as proficient keyboarding.

> The kids may be computer savvy in a lot of ways, but they're not very good at managing information. I've spent a lot of time with them teaching them how to use the computer efficiently and smartly, and even if you only give the kids a few websites, there are some who will have trouble managing that. - Rick

These comments from the focus group interview illustrate that despite the increased access to technology at school and at home, the students still required instruction in web search techniques, file management, and other technical skills. This instruction had to occur during the regular class time and often left teachers feeling rushed. The concern about keyboarding skills was consistent with the research of Grant (2004), and

was identified as a consistent barrier to writing by the participants. All of the positive impacts of increased access to a word-processor in the classroom were mitigated to varying degrees by the individual student's ability to keyboard. A common question teachers had was how and when to introduce keyboarding instruction, whether touch-typing technique was a necessary skill and what method of instruction to use.

Despite the shortcomings in computer skills, teachers reported that all students' skills improved through the year (not surprising with the amount of time spent using the laptops), and attributed some of this improvement to their willingness to help each other with any computer-related questions that came up during classes. A teacher described a class when several students (and the teacher) were having trouble creating a chart in the spreadsheet application. At this point, several students volunteered to demonstrate the process for the entire class using their LCD projector. "...and that's fun. It's fun for them and its fun for us. It makes teaching fun. When they're totally into it, there's nothing more exciting."

Summary

In this chapter, the five themes which emerged from the research in the three classrooms were discussed and compared to the relevant literature, in order to explore teachers' perceptions of what happens to both teaching and learning when students have access to portable computers in their regular classroom space.

Teachers felt there were changes in their teaching and in both how students behaved and learned, as a result of introducing laptop computers into their classrooms. Teachers' beliefs about how technology could be used in teaching changed as a result of ready, reliable access for all students. What began with a 'leap of faith' in letting students have more control over their learning was rewarded with increased motivation and pride in student work and fewer behavioural issues. This in turn, lead to the teachers being willing to take more risks and be more innovative in how they used technology – which engaged students and (teachers believe) lead to better writing, more pride in their work, and a deeper understanding of the curricular material. Teachers began to act more as facilitators and became comfortable designing lessons and projects that were more open-ended and which allowed for a variety of learning styles and abilities. How they worked changed, they relied more on their colleagues in planning, and were reflective in planning learning activities.

Chapter 5: Conclusion

This research aimed to examine what happened in a classroom when each student and teacher was provided with their own laptop computer: Specifically, it explored:

- What happens in a teaching and learning environment that makes use of laptop computers; and
- What are teachers' perceptions of the influence this technology has on their teaching *and* on student learning?

Teachers' beliefs about technology in the classroom changed. They found that having laptops in the space where they normally teach social studies, language arts, math and science, made it much easier for them to integrate technology into those curricula. In addition, teachers reported that not only did the provision of laptops allow them to use a more constructivist approach, but that by giving students more control of their own learning; they actually felt more in control. A fear expressed by participants at the start of the research was that students would be either off-task, or be isolated ("...thirty little bodies sitting at thirty little computers..." – Carly, focus group interview) with the introduction of laptops. In actuality, students were typically engaged and more collaborative when using the laptops when compared with past practice.

As part of the district's *Wireless Mobile Technology* project, these teachers all were part of a new initiative, and worked collaboratively to determine which practices were most promising when using laptops with students. When most successful, this collaboration was centered on curriculum and methods of teaching, and not on the use or management of the equipment.

The findings from this research has parallels to the findings from the ACOT study (Schacter, 1999) where he described teachers' use of technology changing over time as they moved from the 'entry' to the 'adoption' stage, through 'adaptation' to ' appropriation', and finally to the illusive 'invention' stage, where technology is used in novel ways for instructional purposes. The teachers in this study moved along that continuum, each starting at a different point, moving considerably over the course of one school year. They all started at a point which I would describe as being generally around the 'adoption' stage, where they used the technology to support traditional methods of instruction. As they became more comfortable with the technology, and began to realize some of the unique advantages of both increased access and having the technology in the classroom, they came to perceive technology differently. By the end of the school year, the findings show that teachers were approaching the 'appropriation' stage, where the technology was being used as a tool in collaborative projects (Apple Computer Inc., 1995). Laura, who had the least experience with technology, but who

was well-versed in using collaborative projects with her students, showed many indicators of being in this 'appropriation' stage. Rick, on the other hand, was tech-savvy but had rarely used any student-centered learning approaches with his students in the past and showed more examples of being at the 'adaptation' stage by the end of the school year. Carly's experiences fell in the middle of these two, with her limited access to technology probably having an effect on how she was able to integrate technology into her classes.

More specifically, teachers felt that both the quantity and quality of student writing improved as a result of their access to laptops in the classroom. They were much more willing to review and revise written work when it was digital and not on paper. Students had much more flexibility in how they could represent their learning, which lead to teachers feeling like they had a multitude of options available to them when planning learning activities. The excitement expressed by the teachers in the year-end focus group interview demonstrated that the effect of increasing access to technology, and specifically access to laptops, was energizing for teachers and caused them to be more reflective in their practice. Using technology effectively with their students made them feel more relevant, current, and professional.

Recommendations

Reliable access is the key. Without reliable access, teachers will become frustrated and stop planning for the integration of technology. The robust wireless infrastructure installed at each of the project schools allowed for remote management and troubleshooting, and reliable connectivity, and allowed the teachers to focus on curriculum and pedagogy.

The teachers felt most comfortable using the laptops with their students in a way that fit with their teaching style. While the literature reviewed and the research showed a shift towards a more constructivist approach, the participants came to the project with a particular teaching style, and I suspect they will hold on to aspects of that teaching style throughout their careers, as it is part of who they are as teachers. Encouraging teachers to integrate the technology the students are familiar with in a way that coexists with their teaching style will have the most positive and lasting impact.

School districts planning on integrating mobile labs of laptop computers into teaching and learning should consider the issues above, as well as ensure its integration it into a broader, curriculum focused initiative which provisions for the use of technology to support a particular curricular initative (e.g. new provincially mandated curriculum), or other project (e.g. AISI). This will allow for staff to use the technology for their own learning about the new curriculum or project while at the same time plan for how they will integrate it into teaching and learning in their classrooms. With a new curriculum, for example, new units and lessons must be planned, new resources identified, and the access to technology can be used to make this process more manageable and meaningful.

Implications for future studies

A future study could focus on evaluating the long-term effect of teacher and student access to laptops in the classroom. As an increasing number of schools begin to move from computer labs to mobile labs of laptops, there will be a wide variety of samples to compare and contrast, all of which could provide clarity to what, in this study, has been a very positive initiative. Revisiting teachers from this study two or three years from now would be valuable to examine whether the positive effects demonstrated in the first year of this program continued as time passed.

Currently, when most classes use technology, it is technology which is school-owned with consistent hardware and software. As the cost of technology decreases technology becomes more commonplace in classrooms. It is quite a different scenario to imagine teaching a group of thirty students when each one has access to a laptop. It is different again when half of those students have their own camera, video recorder, music player, and half do not. As students begin to bring their own mobile devices (e.g. portable music players, phones, cameras, integrated units) into classrooms, studying how a teacher manages a classroom where a variety of devices are available for accessing a multitude of online resources would be valuable from both a practical and a policy perspective.

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Appendix A: Participant consent forms and participation letter

Mobile Technologies and Teaching

Participant Consent form

Name (Please print):_____

Date: _____

Initials

I have received the letter of information about this research project. _____

I understand that I have the right not to participate in this project. _____

I understand that should I choose to participate in this project, I have the right to withdraw my name without penalty. _____

I have been provided with the means to seek more information about this research project. _____

I have read and understand the above information and consent to participate in the research project including: (Check all that apply)

_____Allowing classroom observations

_____Participating in a focus group interview

_____Allowing data collection from informal conversations

_____ Allowing data collection from entries posted to a reflective journal

_____ _____

Signature of Participant Name of Participant

_____

Signature of Investigator
Terry Korte

Participation Letter

Dear Teacher,

Thank you for your involvement in the project that I am coordinating. I would like to base my M. Ed. Thesis on this project and invite you to participate in the research. The purpose of my research is to better understand what happens in a teaching and learning environment that makes use of portable computing devices. Specifically, my research questions are:

- What are teachers' perceptions of the influence this technology has on their teaching?
- What are teachers' perceptions of the influence this technology has on student learning?

If you agree to participate in the research component, you would be involved in some or all of the data collection activities. These are as follows:

- *Classroom Observations:* When invited, I will observe classroom activities while studentswhere a lesson has been planned which incorporates are using portable computing devices. Observations will include:
    - describing the tasks assigned by the teacher,
    - identifying how the teacher is supporting the students who are using the technology
    - describing the classroom environment
    - describing the tasks students are engaged in,
    - identifying the tools the students are using, and how they are used
    - describing the students' work environment
    - describing / interpreting the nature of the conversations between teachers and students (technical support versus subject-area discussions)

    Notes will be taking during my observations and these will be reviewed with teachers during a follow-up meeting.

- *Teacher journaling*: Each teacher will be asked to make journal entries intermittently through the course of the research. Teachers may keep their journal entries in any format they choose, but one option that will be made available to all participants is to post their journal online using the project website. In order to post entries, participants are required to log in to a secure server which is only accessible to project participants. The entries made to this online journal will not be anonymous among the members involved in the project, but pseudonyms will be used when this research is reported. If someone opts out of the online journal, I would remove their entries and any references to those entries.
- *Notes from informal discussions*: I will make notes from our informal conversations related to the project. I will compile notes from these discussions and they will be given to you to validate.
- *Focus Group Meetings:* All teachers involved in the project will be asked to participate in one focus group meeting at their school. The purpose of this meeting will be to debrief and share experiences in a group setting. This meeting will be audio recorded and transcribed. The focus group meeting will be 45 minutes to an hour in length.

Examples of questions to be posed during the focus group meeting include:

- Did the integration of portable computing devices change your teaching practice? Explain your answer.
- Did the integration of portable computing devices have an impact on student learning in your classroom? Explain you answer.

All data collected from teachers will be compiled and presented as aggregate data.

Participation in this project is voluntary. You should be fully aware that you must expressly agree in writing to participate in the research. There are no incentives for participation, and there are no consequences of non-participation. If you choose to participate in the research, the data collected will be used in my thesis and in publications or presentations relating to this research. To help protect your anonymity, pseudonyms will be used in all research reports, and other information that could specifically identify you will also be omitted (e.g., the name of your school). While pseudonyms will be used and you will remain anonymous, there is no guarantee that complete anonymity can be guaranteed. You will be given a copy of the transcripts so that you can confirm the accuracy of the information presented. You have the following rights concerning this research project:

- You have the right to opt out of the research portion without penalty and any collected data will be withdrawn and not included in the study provided this withdrawal takes place prior to the completion of data analysis.
- You have the right to privacy, anonymity, and confidentiality.
- You have the right to safeguards for the security of the data you provide.
- You have the right to disclose the presence of any apparent or actual conflicts of interests in on the part of the researcher.

Please note that administrators who are in a position of authority will not be informed of who has elected to participate in the research and who has not.

A copy of the final report will be made available to all participants upon request.

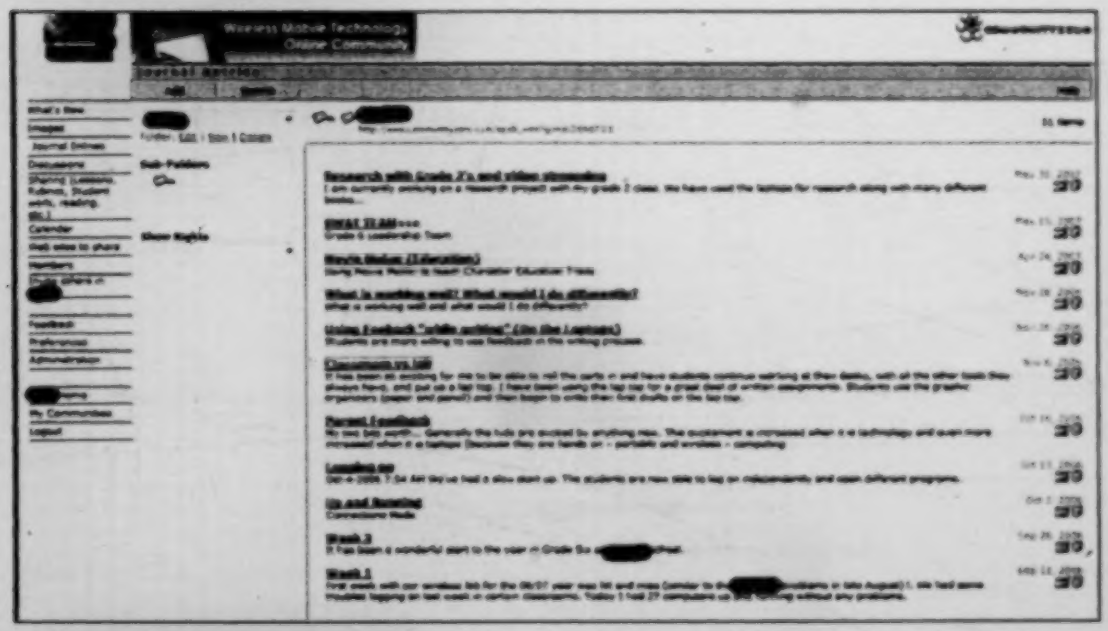
This research complies with the University of Alberta Standards for the Protection of Human Research Participants. The plan for this study has been reviewed for its adherence to ethical guidelines and approved by the Faculties of Education, Extension, and Augustana Research Ethics Board (EEA REB) at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Chair of the EE REB at (780) 492-3751. If there are any concerns regarding consent to participate, this form, or this project, please contact Dr. Norma Nocente, Supervisor (nnocente@ualberta.ca, 492-3676) or Terry Korte (tkorte@ualberta.ca, 265-3450).

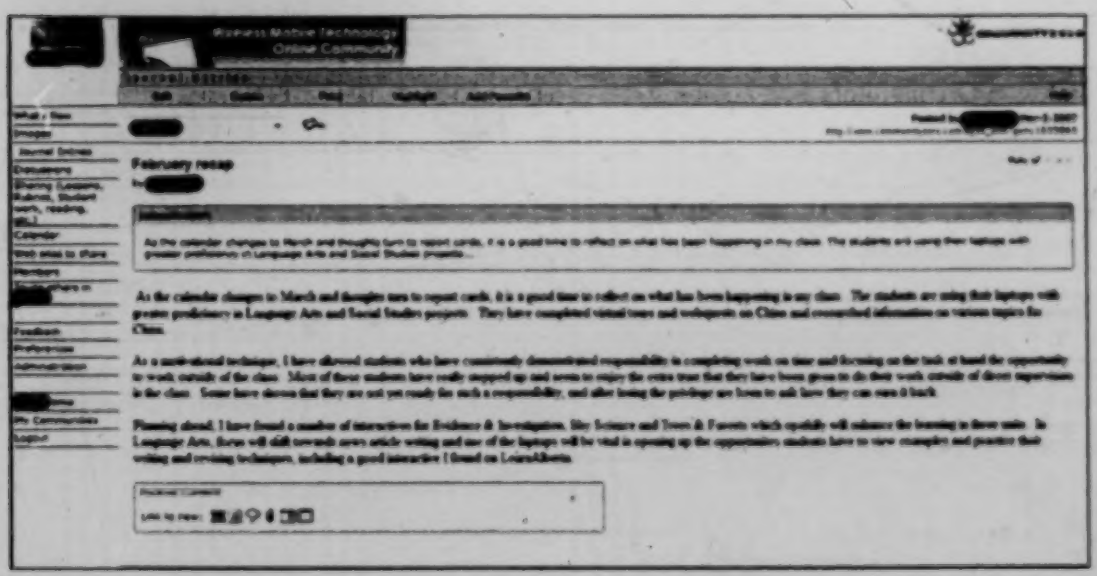
Thank you ,

Terry Korte

Principal investigator

Appendix B: Screenshots from online website





Appendix C: Example of a 'leveled resource' from Forest Park JHS

Space Exploration - The Final Frontier...

What do you know about space?

Is everything you know true?

Step 1: Test your current understanding of space. Complete one of the interactive quizzes on common space misconceptions. Jot down new ideas or questions that you develop about space and space exploration. Be ready to share your questions and ideas with the class.

http://www.space.com/scienceastronomy/fact_fiction_041123.html (10 questions on space theories- questions on first half of page, answers on bottom half, challenging)

http://www.pbs.org/spacestation/seedo/quiz.htm (general comprehension- wide ranging questions and interactive)

http://hubblesite.org/explore_astronomy/way_out/ (NASA's interactive trivia quiz game)

Step 2: Begin to build on your understanding and answer some of your questions about space. Choose from the following websites below. As you explore, jot down any new ideas or answers to your questions. Be prepared to share your findings with the class.

http://www.ers.north-ayrshire.gov.uk/ssques3.htm (interactive website focusing on the make up of our solar system)

http://www.astro.psu.edu/users/stark/links/resource.html (general links page- takes you to a variety of space related websites- pick the site that fits your interest)

http://www.spacetoday.org/Weblinks/deepspace.html (general links page- takes you to a variety of space related websites- pick the site that fits your interest)

http://www.space.gc.ca/asc/eng/default.asp (Home page of Canadian Space Agency- lots of interesting info and links with Canadian perspective)

http://www.nasa.gov/home/index.html (NASA's home page. Need I say more?)

Step 3: On your "exit pass" today, write down the questions or ideas about space that you are most interested in learning. Hand in your questions as you leave today.